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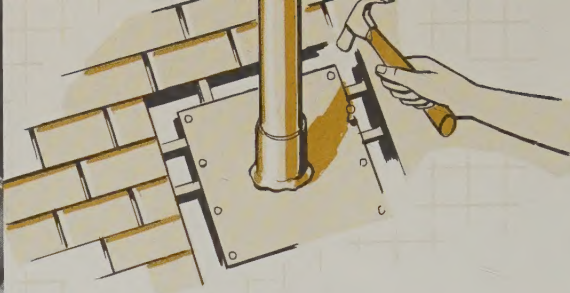
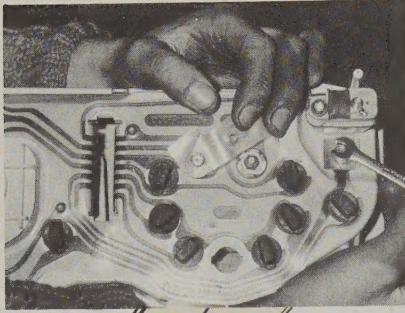


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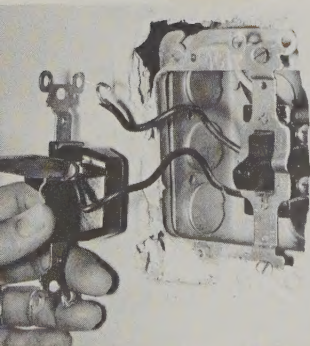
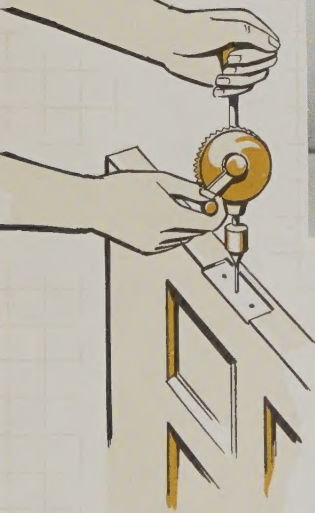
6
DIMMER
ELECTRICITY

do-it-yourself

Complete
Handyman
do-it-yourself
Encyclopedia



do-it



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Complete Handyman yourself Encyclopedia

A COMPILATION OF NEW AND PREVIOUSLY PUBLISHED SPECIAL
INTEREST PROJECTS AND MANUALS FOR THE
REPAIR AND CARE OF HOMES, AUTO,
APPLIANCES, HOBBY EQUIPMENT.
by the editors of

**Science &
Mechanics**

6

DIMMER

ELECTRICITY

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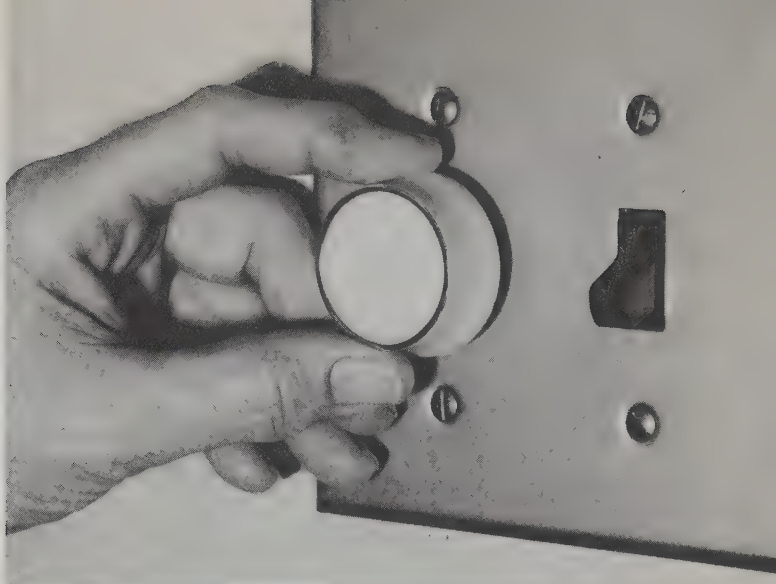
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How to Install Light Dimmers

It's easy to remove your ordinary wall switches and replace them with dimmers that allow you to control the brightness of your lighting by turning a small knob

NOW THAT INEXPENSIVE, easy-to-install dimmers are available from virtually any hardware, department or discount store, increasing numbers of homeowners are discovering the pleasures and advantages of complete light-control.

Using a dimmer. There are times when a given lighting fixture should provide the maximum possible amount of light, as when you read or do close work on a craft project. At other times, all you need is a soft and restful mood light—perhaps only enough illumination to permit walking about in a room without bumping into furniture. And consider this extra advantage: the small cost of a dimmer can actually save money in the long run because you will use less electrical power to operate your fixtures, and because light bulbs last longer if

they are operated at lower than their rated voltages.

Selecting a dimmer. When you shop for a dimmer, bear in mind that although there is a dimmer available for virtually every need, no one dimmer is suitable for every possible use in a home. Some dimmers are intended only for the control of permanent lighting fixtures, others are for table and floor lamps, and still different kinds are required for the control of fluorescent lights. These differences will be made clear later.

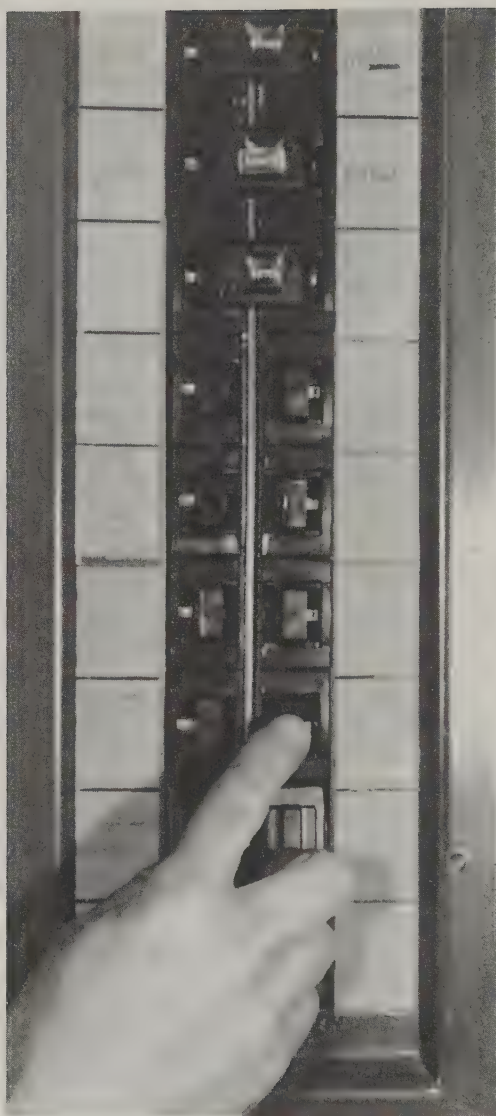
Whatever kind of dimmer you need, keep these basics in mind when you shop. First, do not confuse a bona fide dimmer with a two-level switch. The latter device (adequate in some applications) lets you operate a lamp at full intensity or at one other *single* lower intensity. The kind of dimmer-switch described in this article is generally preferable because it permits *continuous* control of the light level. You merely pull or push the switch knob to turn the light on and off, and rotate the same knob to dim or brighten the light. The switching action works regardless of what light level has been selected.

The most important consideration: select

dinghy: see runabouts

direct ceiling installation: see ceiling tile

directional microphone: see microphones



▲ After turning on all wall switches, push circuit breakers or pull fuses. When lights go out, you are sure that circuit is dead.

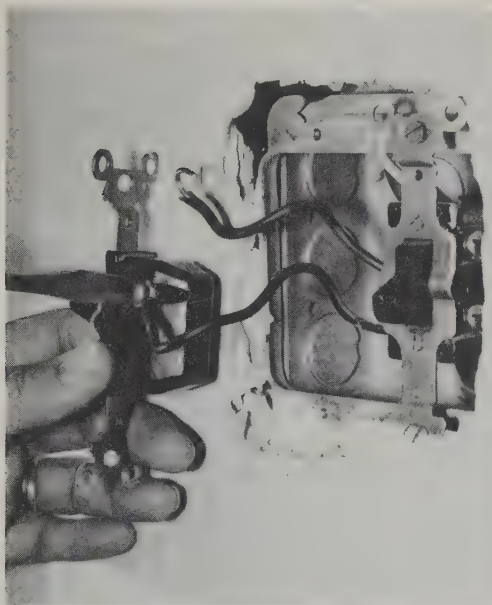
➤ Remove faceplate only after you're sure all lines to that switch have had power cut off.

a dimmer that has adequate power handling capacity for your needs. Most conventional dimmers are rated at about 600 watts. If your fixture, or a series of fixtures operated by the same dimmer draw more power, obtain a dimmer having a higher power rating from your electrical contractor or from a professional supply house.

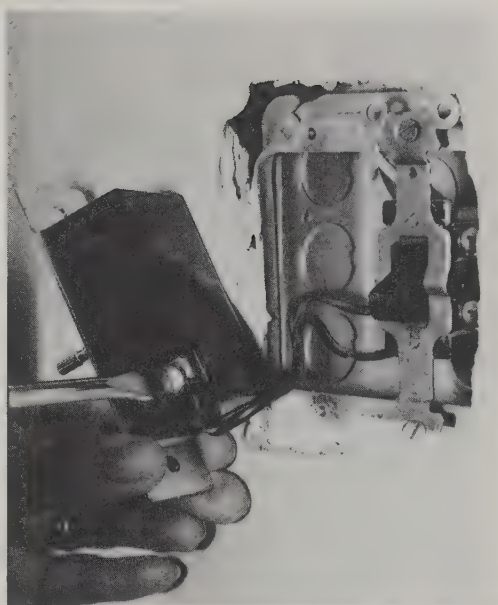
Before buying a dimmer, check the package to make certain that the dimmer has a built-in high attenuation filter which reduces interference with AM radio reception. You are not likely to be troubled by FM radio or TV interference.

Use a single-pole dimmer switch in any





▲ When removing old switch and disengaging wires, try not to damage wire insulation.



▲ Attach wire by wrapping bared end clockwise around terminal bolts and tighten.

circuit operated by only one wall switch. If your lighting fixture is controlled by more than one switch, be sure to buy a three-way dimmer having three rather than two wire terminals.

A good dimmer is not expensive and you will get the best price if you shop around.

Expect to pay somewhat more for a three-way dimmer that would be required for a multi-switch circuit. If you need a dimmer that can handle heavier loads than 600 watts, expect to pay a great deal more. Furthermore, a dimmer for 1000 watts is of relatively large size and will not fit into a conventional wall switch box. A special box is needed.

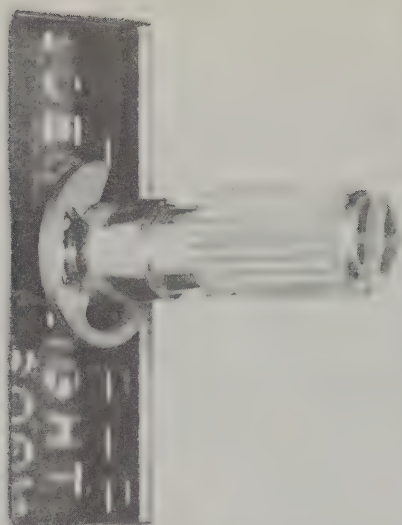
Many of the dimmers (as well as other electrical devices) have the UL or Underwriters' Laboratories label on them. This means that the device is "listed"—that is, Underwriters' Laboratories, an independent testing agency, has tested it and has not found it to contain any electrical hazards. The label does not mean that it is

the best quality, and it definitely does not mean that UL is exhorting you to buy it.

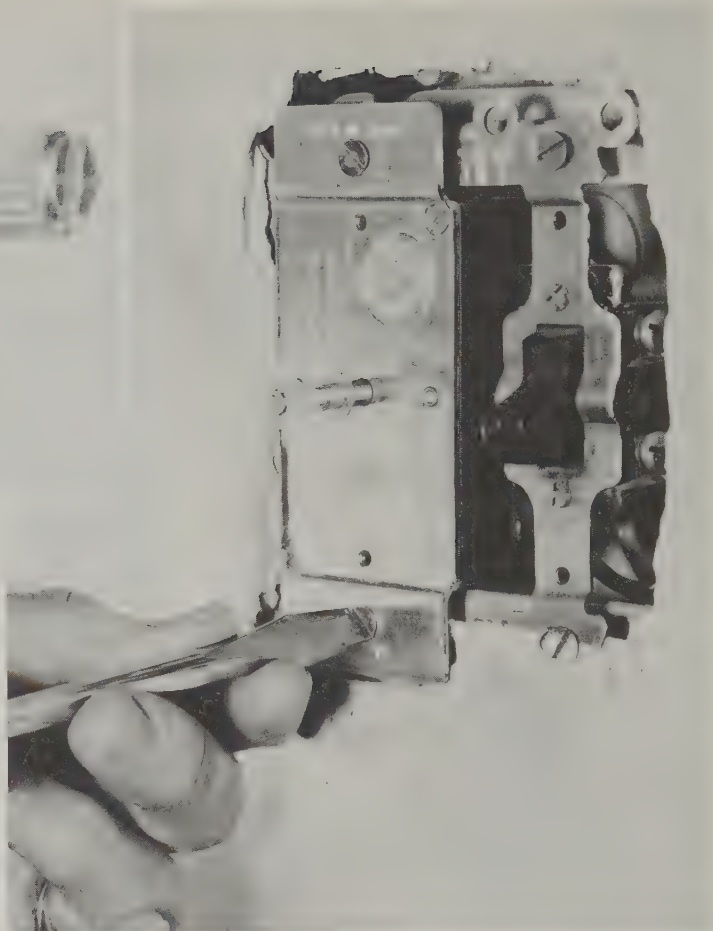
Some manufacturers' products will not carry the UL label, and this does not mean they are unsafe or pose any hazard at all. But if you have doubt, then by all means get the UL-approved dimmer.

You may have to shop around a little more for the 1000-watt dimmer. While large companies do make them, they are not as common as 600-watt dimmers. Try an electrical supply store.

What can you dim? Remember that dimmer switches are used to control *permanent* lighting fixtures only, *not* to control wall outlets to which table or floor lamps are plugged. Why not to wall receptacles? Because sooner or later someone in the family will try to use the dimmer-controlled outlet to operate an appliance that draws too much current (a toaster, for example), or a motor-driven appliance (vacuum cleaner) which could be seriously damaged due to over-heating caused by the reduced voltage.



▲ Split washer (inset) on dimmer shaft must be flush with the outer level of the box faceplate to work. ➤



Also, any radio or TV set subjected to a reduced voltage level will not function properly. A dimmer is *not* suitable for controlling the speed of power tools such as a drill or saber saw. If you wish to reduce the speed of a tool driven by a universal AC-DC motor, buy a speed control device made especially for that purpose.

The instructions provided by some dimmer manufacturers specifically state that the dimmers should not be used to control wall receptacles. Other manufacturers fail to emphasize this warning, probably because they do not wish to discourage dimmer sales. In any case, assume that the prohibition applies whether or not a dimmer package has a specific warning.

Any dimmer you are likely to find in a hardware, department or discount store can be used to control *incandescent* lights *only*. To control a rapid-start fluorescent light you need a special type of dimmer that includes a supplementary ballast.

How to install. A dimmer switch can be installed in minutes using only a screwdriver. Start by turning on *all* of the switches in the box where a substitution is to be made. Now pull the fuses, or punch the circuit breakers (on your service panel) that provide power to the lights the wall switches have turned on. When the lights go off, you are sure that circuits in the switch box have been deactivated. The reason for turning on all switches in a multiple-switch

How to Install Light Dimmers

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box is that often a single switch box is powered by more than one branch circuit. If you cut off only one of these circuits, the live one could kill you.

Now remove the face plate of the switch box, and take out the switch that is to be replaced by the dimmer. All you need to do is attach the two wires in the switch box to the dimmer terminals, screw the dimmer in place, replace the face plate and switch knob (be sure that split washer on dimmer shaft comes out far enough to coincide with outer level of box faceplate). If the dimmer you purchase has two protruding wires instead of screw terminals, make connections by twisting wire ends together and then adding plastic screw-on insulating connectors.

If the lighting fixture to be controlled is operated by several switches at different locations—at the top and bottom of a staircase for example—be sure to use a three-way dimmer. Installation is just as easy except that you connect three rather than two wires to the dimmer switch.

Remember that all dimmers generate small amounts of heat. This is no problem unless you place more than one dimmer into the same switch box. Where dimmers are ganged, *de-rate* each dimmer according to the manufacturers instruction. For example, if you put two 600-watt dimmers into the same switch box, each dimmer is de-rated to a maximum of 500 watts. If you put three dimmers into the same box, de-rate each to 400 watts. Thus a two-dimmer gang provides only a total of 1,000 watts capacity instead of 1,200 watts and a three-dimmer gang provides a total of 1,200 watts, not 1,800 watts. If the dimmers are installed in separate boxes where their heat effects are not additive, you can of course control up to 600 watts of lighting power with each dimmer.

Note also that there are specified *minimum* wattage requirements for each dimmer. Typically, dimmer wattage *ranges* ex-

tend from either 40 or 75 watts to the maximum of 600 watts.

Dimmers for table lamps. As we said, it is not a wise idea to control wall receptacles in order to dim table or floor lamps. Not only can this lead to serious electrical troubles, but it would be very inconvenient to have to walk to a wall switch to adjust the light level of a distant lamp.

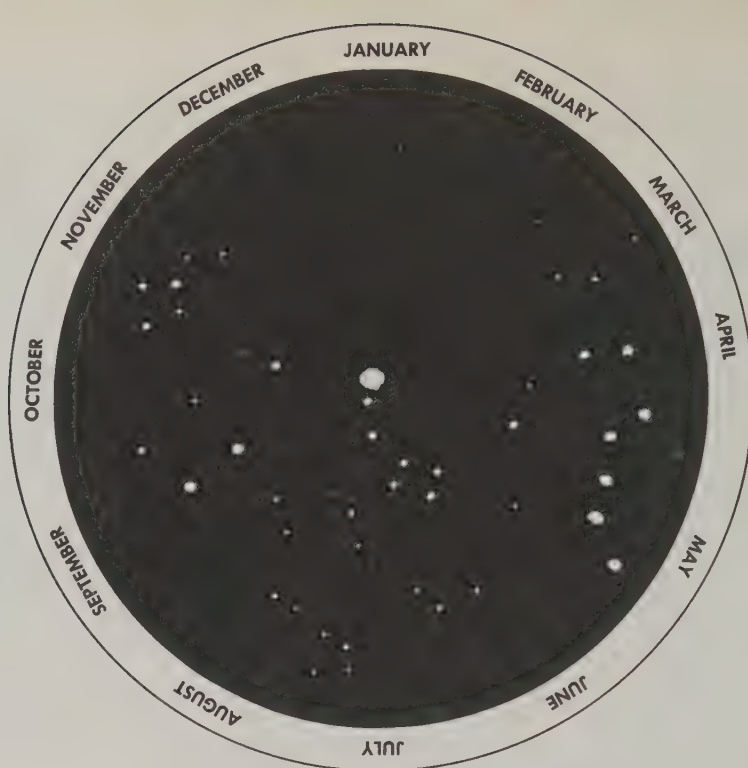
There's a much better way to solve the problem. Use a dimmer especially made for the control of table lamps. The most popular variety consists of a small control box that you place on the table, next to the lamp. Just plug the dimmer power cord into a wall socket and plug the lamp into the dimmer socket. Immediately, you are able to dim or brighten the lamp next to your favorite chair.

J.H.

See also: ELECTRICITY.



▲ One kind of lamp dimmer simply screws into bulb socket. This dimmer handles up to 250 watts.



▲ Photogram shows northern sky as it appears throughout the year at night. Turn page so current month is at top, and you'll see how sky will appear at 9 tonight.

Wilderness Direction Finders

How to use the heavens to find your way, day or night, or tell what time it is, without compass or clock

PRIMITIVE MAN recognized the cardinal points from natural signs. Most prominent was the polar star—a twinkling, pinprick of light that remained mysteriously motionless in the northern sky while the rest of the heavens revolved around it.

It wasn't the same North Star we use today. For primitive man, the stationary star in the northern sky was Alpha Dracons in the constellation Draco. By the time Cheops started building the great pyramid in Egypt, the North Star was Thuban, also in Draco. His workers used it so well

that the huge pyramid is lined up within one-twentieth of a degree of true north.

This shifting of the North Star comes from an astronomical phenomenon called precession of the equinoxes. It means the earth wobbles on its axis, and the pole points to different stars as time goes by. Two thousand five hundred years from now the North Star will be one of those on the west side of Cepheus. In 14,000 years it will be Vega, in the constellation Lyra. But if you can last until sunset tonight, it will still be Polaris.

Take a look at the photogram. Hold the page so the month of May is at the top.

Directly beneath May is the Big Dipper—a constellation the ancient Greeks used to guide their ships at sea (apparently they were between North Stars). With May at the top, the Dipper is upside down. Its stars

Wilderness Direction Finders

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are somewhat larger than life-size scale for easy identification.

The two stars at the lower left—the outside of the Dipper’s “bowl”—are called the pointer stars. They point, along a line drawn through them, to Polaris—the North Star.

Polaris is the bright one in the photogram’s center. It’s at the handle end of the Little Dipper, which is easily distinguished. The faint line of stars curling off toward August is Draco, already mentioned.

Down near November is the “W” shape of Cassiopeia, the Queen; between Cassiopeia and Draco is the five-star, boat-shape constellation Cepheus, the King.

Learn these and you know the major circumpolar constellations. You’ll always be able to glance at the sky and locate the North Star.

The big Dipper, you see, wobbles its way below the horizon in the southern part of the United States during the early part of winter evenings. It doesn’t become visible until about two or three in the morning, rising on the right, or east, of Polaris.

All the circumpolar constellations swing counterclockwise around the North Star. Hence the photogram—which was made by photographing light shining through patterned pinholes in aluminum foil.

Hold the photogram so the current month is at the top. This will always show you how the northern sky would look after sunset—at about nine o’clock. To see how it would appear two hours later, use the next latest month; four hours later, skip to the second month. A quarter-turn (putting August at the top) will show you how the northern sky would look at three a.m. in May.

This is why modern outdoorsmen can’t easily locate the North Star. They know how the Big Dipper looks, but never understood the counterclockwise rotation. The Big Dipper just isn’t in the same place every hour or every night.

Study the photogram and you’ll know how to find the North Star any night of the year. Even if you live in the south, and the Dipper is occasionally out of sight below the horizon. Cepheus and Cassiopeia are just as unmistakable, and they help you pinpoint Polaris.

The North Star, of course, does not move. Well, not very much; it does wobble a wee bit. But the motion is so slight it is of interest only to offshore navigators “shooting” Polaris for a latitude sight—and they know how to adjust for the very tiny error.

That’s the North Star’s most useful aspect for navigators: its altitude above the horizon, measured in degrees, equals the observer’s latitude (distance above the equator).

Make a plumb bob from a fishing sinker and bit of line. Attach it to the center of a dime store protractor’s straight edge. Sight the North Star along the straight edge, pinch the string, and read the altitude in degrees. Read it right, and you’ll get an answer equalling your latitude. You’ll also know how Christopher Columbus managed to find his way back home from the New World; he used Polaris for latitude sights.

They didn’t know anything about longitude (east-west distances) in those days. So Columbus utilized a technique known as latitude sailing: get on the known latitude of a desired destination, then sail east or west until you reached it.

Otherwise, Columbus used Polaris much as the herdsman and hunter of the inland hills; as a guide to true north. In fact, the navigators of his time applied Polaris as a check on the crude compasses. The ship’s pilot would sight along the upper edge of his palm, line it up on the North Star, then bring it down smartly to the compass to make certain the needle was accurate. Superstitious sailors called this mysterious act the “Pilot’s Blessing.”

Which may all be interesting to the average outdoorsman, but seems of little prac-

tical value—outside of providing useful background and maybe material for a campfire yarn or two.

But you can make obvious use of Polaris and the circumpolar constellations. And not just for an infallible guide to true north.

You can tell time by the stars. As already noted, the circumpolar constellations rotate counterclockwise around the North Star: 45 degrees in three hours, 90 degrees in six hours, a full 180 degrees in 12 hours.

This in itself is sufficient guide to add much to your woodlore. Study the photograph until you understand how the constellations move around the North Star. Then you can merely glance at the sky, announce "It's about midnight, I reckon," and puzzle campmates.

But if you want to really amaze them, memorize this little formula. It can be astonishingly accurate, if worked with care.

Think of the North Star as the center of a giant clock; think of the Big Dipper's pointed stars as the hour hand.

Estimate, with as much care as possible, the imaginary "hour" to which this heavenly hour hand points. Just as if it was on a real clock. If you're able to do so, allow for the half hours. Then follow the formula:

1. Add to the hour figure the number of months since January 1-to the nearest quarter, or week.

2. Double this new figure.

3. Subtract it from sixteen and one-quarter. If the figure is too large, then subtract it from forty and one-quarter.

4. The answer is the hours (and half hours) since noon.

It's not as complex as it sounds. Here's an example:

Suppose the pointers suggest eight o'clock, and it's June 15.

June 15 is five and one-half months from the first of the year. Eight (o'clock) plus five and one-half equals thirteen and one-half. Doubling it gives you 27.

That's too much to subtract from sixteen

Wilderness Direction Finders

and a quarter, so take it away from forty and one-quarter. The answer is thirteen and one-quarter, or thirteen hours and fifteen minutes past noon.

Or, as you've guessed by now, 1:15 a.m. Simple. Not as simple as a watch, but a handy outdoor trick well worth knowing. Besides, practicing to tell time by the stars teaches you to always find Polaris with ease. You'll always know true north. And it's still man's favorite direction, for you can't find the other cardinal points until you first locate north.

But what if it's broad daylight? No Polaris?

Still simple. And we go back to primitive mankind once more.

Our hairy-browed ancestors were able to locate true north very accurately in the daytime. They used the sun.

Not at daybreak. Contrary to what some otherwise well-informed outdoorsmen may think, the sun does *not* always rise in the east. Depending on your latitude and the season of the year, it may rise well to the north or south of true east. It appears in the east only at the equinoxes—or approximately March and September 22. (And for a few days before and after.)

When man was more universally oriented to the outdoor world around him, this fact was more widely known and appreciated. And man learned early how to get around this inaccuracy in the sun's motion.

He drove a stick in the ground and attached a length of cord to its base. The cord was held at the end of the pole's shadow, and swung in an arc. The arc was scribed on the ground with a second stick or sharp stone. Then a stone was placed on the spot where the sun's shadow first touched the arc.

Hours later, past midday, the sun's shadow would once again touch the arc—on the opposite side. A line connecting these two points extended due east and

Wilderness Direction Finders

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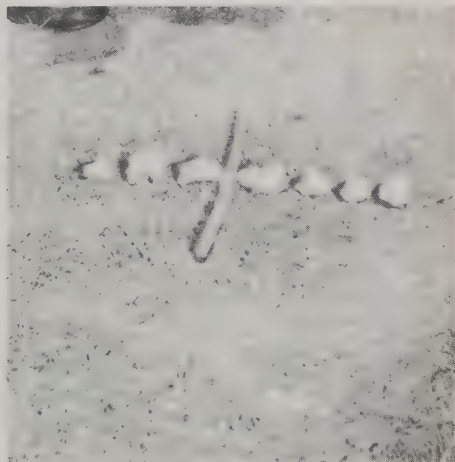
◀ To find north in daytime, place stick upright in ground and mark end of its shadow with stone.



➤ As shadow moves, place second stone on shadow's tip.



◀ Repeat with a third, fourth or even more stones, placing each at end of stick's shadow as shadow moves.



➤ You will have a row of stones, lined up in a true east-west direction. Placing stick perpendicular to stones gives you the north-south line.

west. Any perpendicular line would then indicate north and south.

It was accurate enough for early man to line up his buildings and principal streets with the cardinal points. But it suffered from delay; it took most of the day to find man's favorite direction.

A few years ago a youngster dreamed up a variation on this ancient theme—and the U. S. Army, fascinated by a twist on forgotten lore, paid the boy handsomely for his idea.

Here's the modern twist—and it's illustrated in the series of photos:

Jam a stick in the ground. Place a stone at the end of the sun's shadow. Wait until

the shadow moves appreciably, as it will in a few minutes.

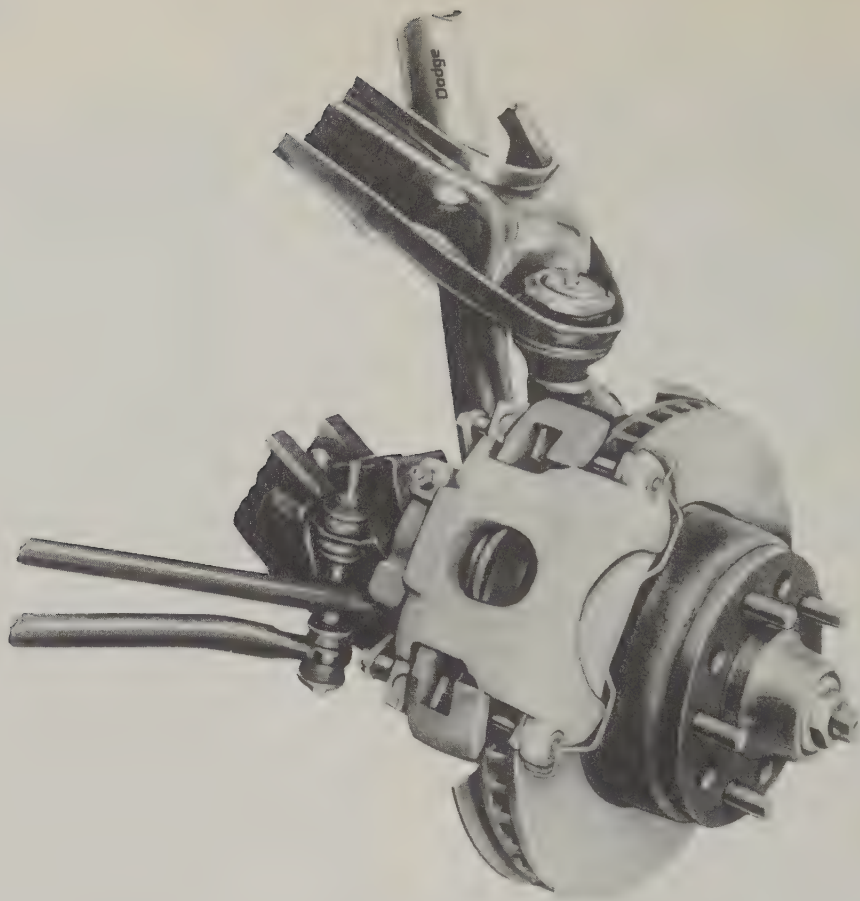
Then place a second stone at the shadow's tip. Repeat the process, placing stones at the shadow's end as soon as it noticeably moves to a new spot. Eventually you have a line of stones.

In perhaps a half hour of time, they'll point due east and west with remarkable accuracy.

Use the North Star at night. Use the sun, a stick, a handful of stones in the daytime. If it is overcast and you need to know north because you're lost, just wait awhile until it clears up.

J.M.

See also: CAMPING; HIKING.



▲ This is a typical floating caliper disc brake. Caliper floats along rods attached to brace. In this type, only one side of caliper has piston.

Servicing Your Disc Brakes

They eliminate the problems of brake overheating and wet brakes, and new developments making the system easier to maintain give discs an added plus

DISC BRAKES can be installed on the front wheels of virtually all cars, and some cars even offer discs front and rear.

Instead of pumping fluid into wheel cylinders, the master cylinder of a disc brake pumps the fluid into a hydraulic piston device called a caliper. The caliper is much

like a clamp. As pistons are pushed out by fluid pressure they squeeze a pair of friction pads against the sides of a disc. The disc is bolted to the wheel, just like a brake drum, and when the pads are clamped against it, the car is brought to a stop.

Because the disc is exposed to the air to keep it cool, the system is virtually immune to fade caused by heat, the brake system's number one enemy. The disc also spins off water, so driving through a deep puddle does not cause extended loss of braking efficiency.

The front wheels do two-thirds of the brake work on a typical car, so the discs

Servicing Your Disc Brakes

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are usually installed on the front wheels. The old drum brake is better as an emergency brake, so many companies still fit drums to the rear wheels. The reason the drum does better as an emergency brake is the self-energizing effect, which is the wedging action of the shoes into the drum. This wedging action reduces the pedal pressure necessary for braking effort, and also the pulling action on the hand brake (or pushing action on the foot-actuated emergency brake). Because it has no self-energizing effect, the disc brake usually requires a power assist, particularly on larger cars.

In the drum braking system, return springs retract the shoes, so for fast response when you hit the pedal, a small amount of residual pressure is maintained in the hydraulic lines by that residual pressure check valve in the master cylinder. The disc system has no return springs, so it has no residual pressure check valve. It gets its fast response by keeping the friction pad lightly touching the disc or just a few thousandths of an inch away.

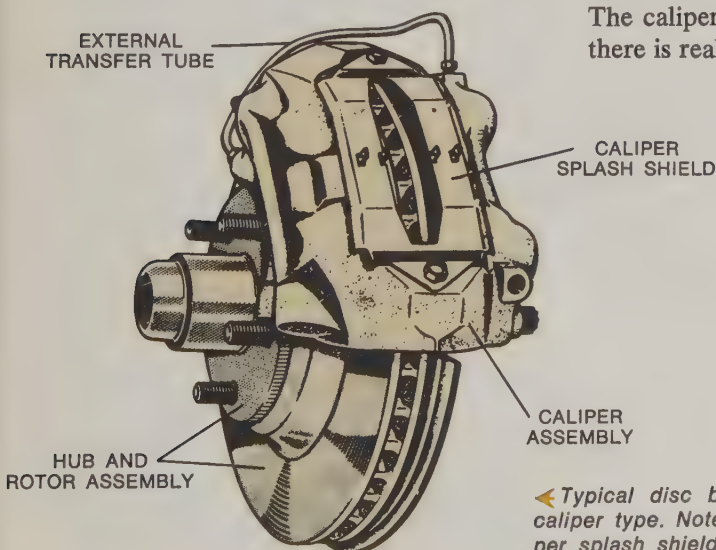
Because it does not retract the shoes, the disc braking system is self-adjusting. As the friction material on the pad wears, the piston pushes out further to press the fric-

tion pad against the disc. There is no spring to retract the piston, so it keeps its new position each time.

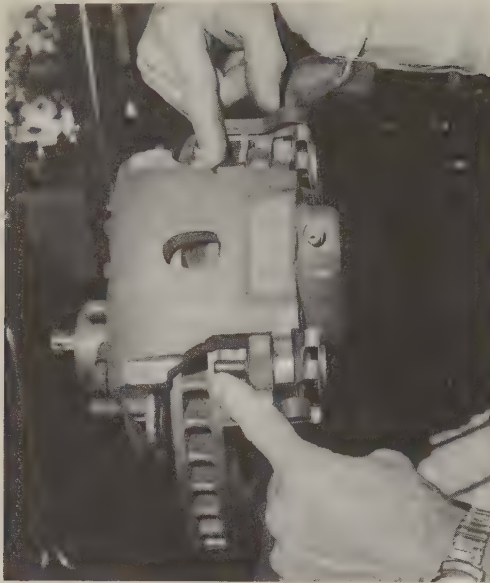
The absence of residual pressure in the lines keeps the brakes from dragging when you take your foot off the pedal. Some disc systems retract the piston mechanically (often with nothing more than a flexing seal around the piston) a few thousandths of an inch to eliminate drag of any sort. Others actually use a spring behind the piston to keep the friction pad and disc in light contact.

Two disc braking systems have been used. The first was the fixed caliper type, used in the sixties. The caliper is bolted in position around the disc, and has one or two pistons on each side to push the friction pads against the disc. Most American cars now use a floating caliper design. It has just one large piston.

The caliper floats a few thousandths of an inch along a bracket that is fixed over the disc. The single piston comes out, pushes the pad in front of it against the disc, and the caliper floats opposite to the direction of the piston. This movement pulls the other side of the caliper into the other side of the disc. The friction pad on this side then is pressed against the disc. The caliper moves very little in its float so there is really no obvious movement.



◀ Typical disc brake setup of the old fixed caliper type. Note the cover plate (called caliper splash shield) over end of caliper.

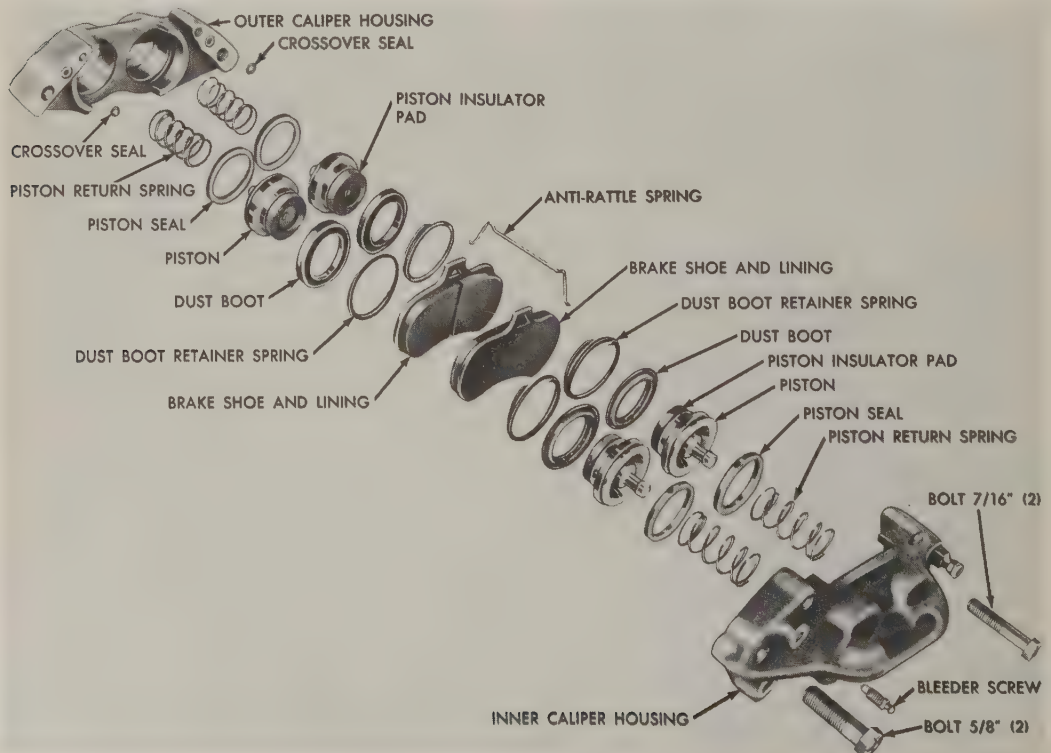


▼ *Disassembled fixed caliper. Notice four-piston design. Grooves in brake shoes are wear indicators. When groove wears away, it is time to replace shoe.*

◀ *This type of floating caliper disc brake has been used by Ford. Fingers point to bolts along which the caliper floats.*

The basic repair on a disc system is replacement of the friction pads, the equivalent to fitting new brake shoes on a drum system. It is a job the weekend mechanic can easily do. The first step is to see if the pads need replacing. On most disc systems, you can see the condition of the pads simply by looking in through the end of the caliper. You may not even have to pull a wheel.

On most American disc brake systems, there are slots to a certain depth in the friction material, and when these slots are worn away, the pads must be replaced. The pads should wear evenly, and about the same on both sides, so if you can see what one pad looks like, you can safely assume the condition of the other. Pads on some disc brake systems wear to a slight taper



Servicing Your Disc Brakes

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(normally a maximum of $\frac{1}{8}$ -inch). The pad should be at least $\frac{1}{32}$ -inch thick at its thinnest point.

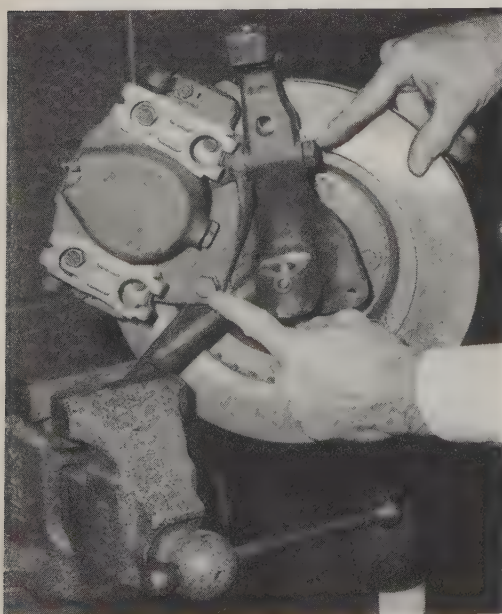
Begin pad replacement by siphoning out a few ounces of fluid from the reservoir if it is full. Otherwise, when new pads are installed, and the pistons are forced further back into the caliper, they will displace fluid, pushing it up through the lines into the master cylinder, causing it to overflow. Discard the siphoned-out brake fluid. If the master cylinder was not topped up as the pads wore and the pistons projected out, there will be no need to drain out fluid.

The fixed caliper design is the easiest in which to replace pads. In virtually all cases, there is a cover plate (held by pins or screws) on the edge of the caliper. Take off the cover plate and pull out the old friction pads. You may have to work the pad back and forth a bit to gain the clearance to pull it out easily. Now push the pistons back in. (If they won't go back in, the caliper must be overhauled.) To gain the proper leverage, insert a small piece of steel and exert force against the steel with a large screwdriver (which will protect the aluminum

pistons against scoring). Once the pistons are back, you can push the new pads into place. Refit the cover plate and the job is done.

The floating caliper design takes more time. One type has a caliper bracing plate (to and from which the caliper floats) attached to the spindle. Two bolts hold the brace, and once you remove these, the caliper and brace drop as a unit. If you are careful, you will lower the caliper onto a box and work at the wheel. Otherwise, you will have to disconnect a brake line and bleed afterwards. The friction pads may be held by guide pins or slots in the caliper. When you refit the brace, tighten the top bolt first. Each bolt should be tightened to factory specifications, normally 90-100ft./lbs. using a torque wrench.

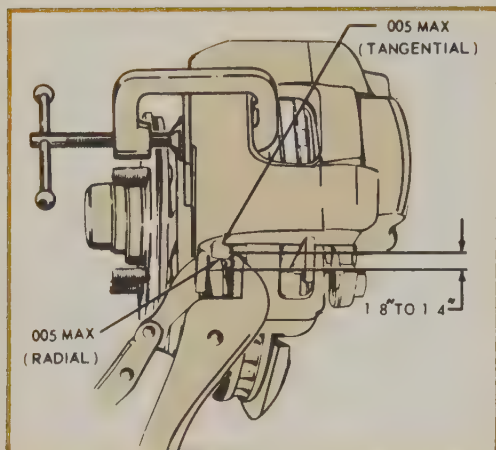
The other popular design has a bracket bolted to the spindle and the caliper mounts to the bracket on two bolts, along which it



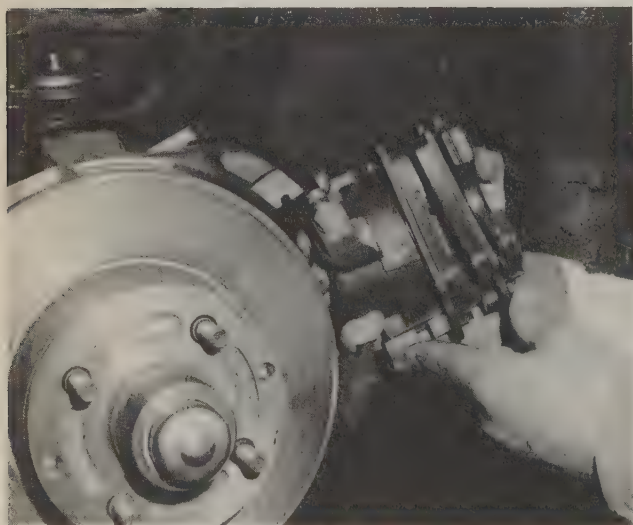
▲ Pads on that Ford system are easily removed once caliper is lowered. (It is shown on bench for illustrative purposes only.) Piston can be pushed back with thumb pressure.

◀ Fingers point to bolts which must be removed (on aforementioned Ford floating caliper discs), to pull away caliper and bracing plate for access to friction pads (brake shoes).

floats. To change friction pads, undo the bolts and remove them. This allows you to lower the caliper from the disc. With the caliper lowered, the new pads can be fitted



▲ Outboard friction pad had to be aligned by clinching on early GM floating caliper disc brakes. Clinching was done by holding assembly onto disc with C-clamp and bending ears of the friction pad (brake shoe) with vise-type pliers.



▲ This design of floating caliper disc brakes is simple to service. Clips are removed from end of float rod, then rod is pulled with pliers, permitting removal of caliper. Once caliper is off, float rod guides are slid out, freeing friction pads.

into place. (There may be a spring between the caliper piston and the inboard shoe; if there is, be sure to reinstall it.)

The sleeves and bushings through which the float bolts pass should be replaced when installing new pads, to be sure the caliper will continue to float properly. Lubricate the sleeves and bushings and the small ends of the bolts with a silicone grease.

Once the pads are in position (on some early models the outboard pad must have its ears properly lined up), begin a process called "clinching." This is done by starting the caliper with new pads back onto the bracket, so that the bottom edge of the outer pad is just resting on the outer edge of the disc. Clamp the outboard pad to the caliper with moderate pressure, using a C-clamp. (The caliper is cut out at the outer end, so you'll need a metal plate, such as an old brake pad, to span the opening.)

With vise-type pliers, clinch the outboard shoe ears as illustrated. Locate the pliers $\frac{1}{8}$ to $\frac{1}{4}$ -inch from the outer edge of the ear. The clearance of the ear from each edge of the caliper should be no more than .005-inch, as illustrated.

Floating caliper discs were changed in 1970 to eliminate the need for clinching pads.

The condition of the disc itself is important, of course. But scratches .015-inch deep, which would certainly require refinishing of a drum, do not require attention on a disc. Previously, a badly scored disc had to be replaced, but the manufacturers of brake drum lathes now have attachments that permit perfectly acceptable refinishing of discs.

As you can see, there is nothing complex about disc brakes. In fact, when you compare them to today's self-adjusting brakes, with their complicated system of links and springs for self-adjustment, they almost look simple.

See also: DRUM BRAKE SERVICE.

How to Repair Your Dishwasher

You can identify the causes of most dishwasher breakdowns. Save money by replacing the parts yourself

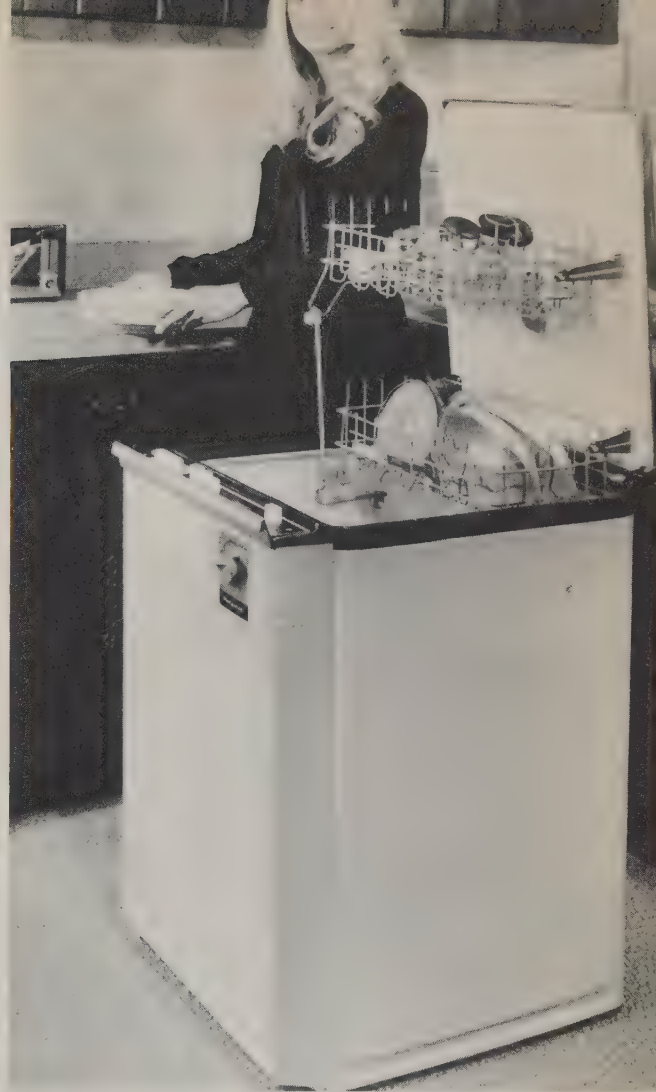
YOUR DISHWASHER is designed to wash, rinse and dry dishes automatically. When properly installed, used and supplied with suitable water it will do a better job than hand washing. As with other appliances, knowing your machine's capabilities and limitations will do much to give you more satisfactory results. Prepare your dishes as well as you would if you were doing them by hand!

Read your Owner's Manual. Incorrectly placed dishes will prevent good washing action in some areas of the machine.

Water. Poor water quality, resulting from dissolved minerals, can ruin an otherwise perfect dishwashing job. That cloudy film on glasses and the white spots on flat-ware are minerals from the water which remain when the water evaporates during the drying process. If you're in a "hard water" area check your water source before condemning your dishwasher for poor results.

Usually these white spots are calcium (lime) deposits and can be removed with a vinegar wash. Do it this way:

1. Run your dishes through a normal cycle up to the drying period.
2. Advance the timer to the wash cycle and allow the machine to fill.



3. Add two cups of vinegar—no detergent.

4. Allow machine to complete the cycle.

This should remove the lime deposit. If some still remains repeat the process.

A water softener may be the final answer to obtaining better quality water.

Installation. Another point to check before blaming your machine for poor results is the installation. Requirements are simple but must be met. Domestic dishwashers are designed to operate on a 115-volt, 60-cycle branch circuit provided with a 15-ampere time delay type of fuse. It would be a good idea to use no other appliance on this circuit at the same time.

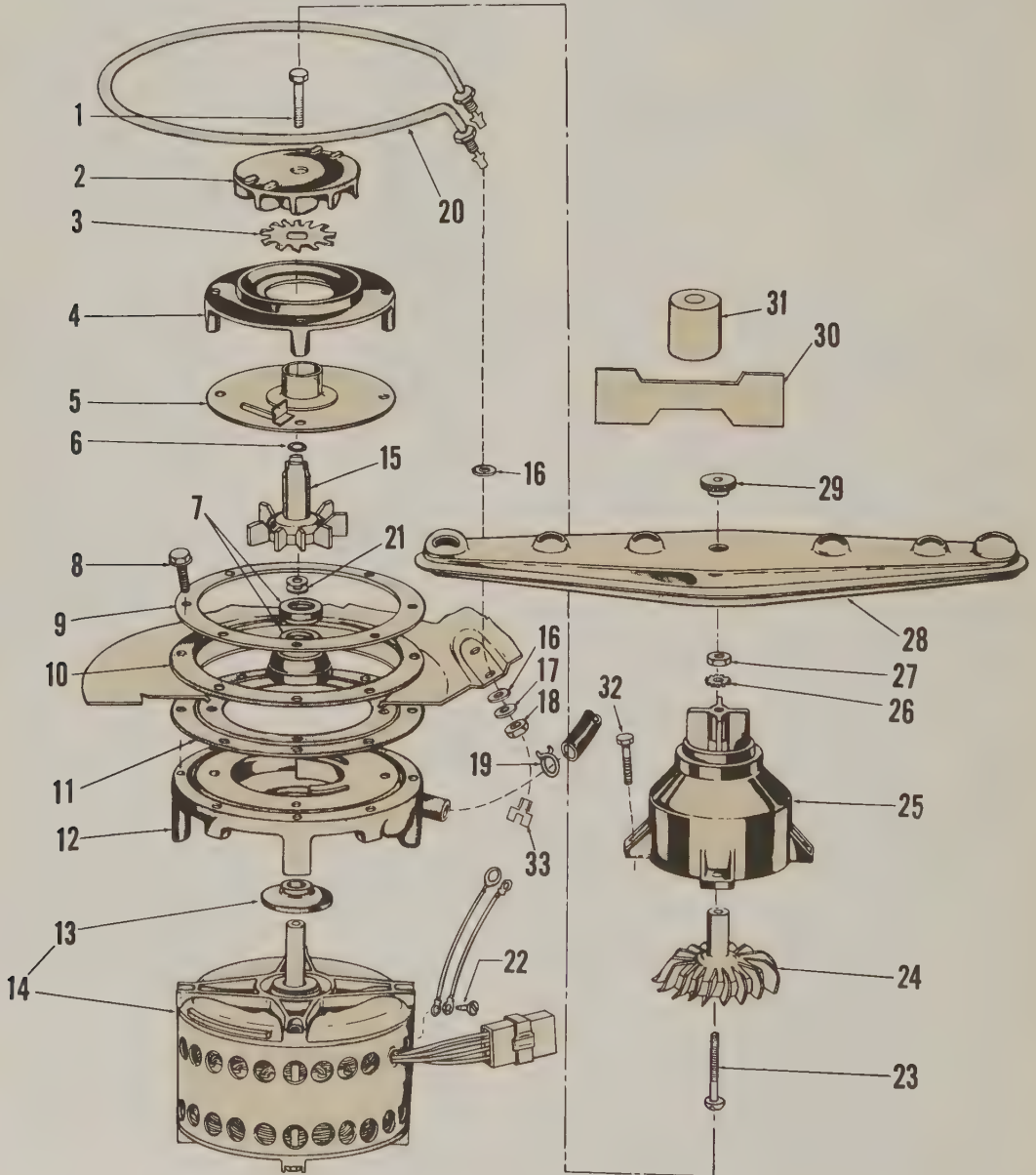
disk sander: see abrasives
dispenser, paper: see paper dispenser, kitchen
displacement hull: see hulls

Your dishwasher must be grounded to reduce shock hazard. Portable machines are grounded through a three pronged plug. If the wall receptacle is for the standard two

pronged plug an adapter must be used. Be certain the adapter is properly grounded. A permanently installed machine is grounded through the wiring cable, or by a separate wire connected from the machine frame to a water pipe.

Water pressures greater than 120 pounds per square inch at the dishwasher may damage the fill valve or fill hose. A pressure

✦ Exploded view of the water recirculating and drain system of a typical spray-arm type dishwasher. Use the key on page 793 to identify numbered parts.



REF. NO.	PART NAME	QTY.
1	Number 10x1 $\frac{1}{4}$ " Hex Washer Head Stainless Steel Screw	1
2	Impeller—Upper	1
3	Blade—Macerator	1
4	Plate—Spacer	1
5	Plate Assembly—Pump	1
6	"O" Ring	1
7	Seal	2
8	Number 10—32x $\frac{3}{8}$ " Hex Washer Head Stainless Steel Screw	As Required
9	Cover	1
10	Gasket	1
11	Gasket	1
12	Pump Housing Assembly	1
13	Slinger	1
14	Motor Assembly	1
15	Impeller—Lower	1
16	Gasket	2
17	Washer	1
18	Nut $\frac{1}{2}$ "—20 Brass	1
19	Clamp	As Required
20	Heater	1
21	Shims	2
22	Screw	As Required
23	Number 10—32x2 $\frac{1}{4}$ " Hex Head Stainless Steel Machine Screw	1
24	Diffuser	1
25	Housing—Pump	1
26	Number 10 External Tooth Lockwasher .	1
27	Nut 10—32 Stainless Steel	1
28	Spray Arm Assembly	1
29	Nut—Spray Arm	1
30	Shim Gage	1
31	Seal—Installation Tool	1
32	Number 10x1 $\frac{1}{2}$ " Hex Washer Head Stainless Steel Screw	4
33	Terminal Adaptor	1

reducing valve should be installed in the water supply line entering your house to protect the entire water system.

Water pressure lower than 15 pounds per square inch will not allow enough water to enter the machine. Low water level will result in poor washing action and unclean dishes.

If your water supply can deliver a flow of three gallons per minute at the kitchen sink there should be no trouble on proper fill. Take a watch and a gallon jug and see whether the jug gets filled in 20 seconds or less. A two quart milk container should fill in 10 seconds.

A water temperature range of 140° to 160° in the machine is important. Detergents for dishwashers have ingredients that need this temperature to dissolve. You

can't get clean dishes with cold water, nor will they dry. Proper drying requires that the dishes be hot at the beginning of the drying cycle.

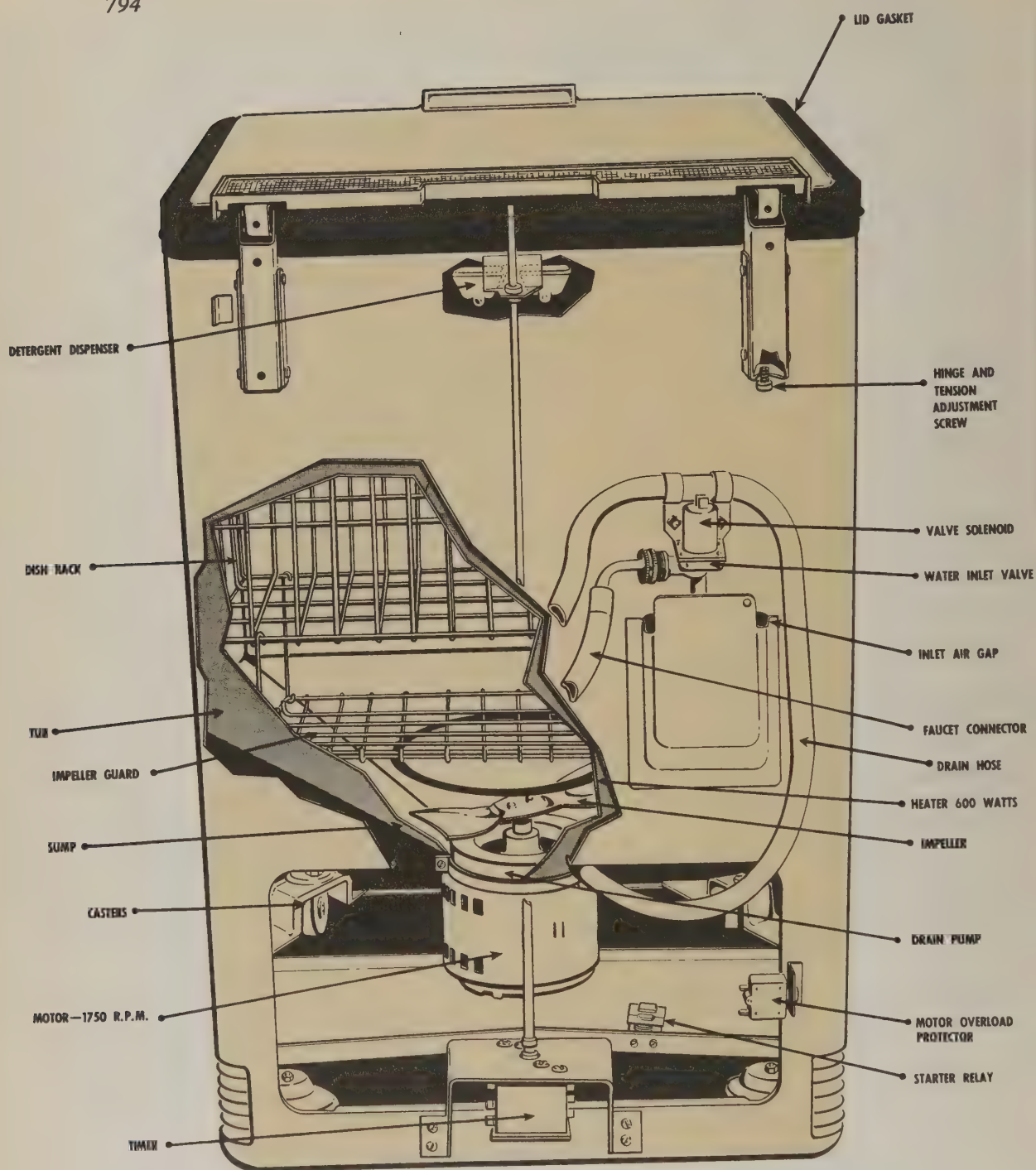
Operation. To wash dishes a dishwasher sprays or splashes a hot solution of detergent and water over the dishes. Both methods are in general use. In both instances the force of water on the dishes knocks off the soils. The detergent then attacks the soils and holds them in solution.

Spray action is obtained by a rotating arm having a row of jet holes through which pumped water will spray against the dishes. Some of the holes are at an angle to provide a jet thrust for rotating the arm. These machines have a filter screen that separates particles of soil from the water, preventing them from redepositing on the dishes. It is important that these screens be properly fitted, otherwise large soil particles will clog the spray arm jet holes. Normally these large particles collect in a scrap basket which must be cleaned regularly. Sometimes foreign matter will collect under the spray arm bearing surface causing the arm to move slowly or stop. When this happens the arm must be lifted off the hub and cleaned.

Splash action is obtained by an impeller, partially submerged in water, at the bottom of the machine. This scoops the water upward and outward, slinging it against the dishes. These machines have no screen to prevent soil redeposition; therefore dishes must be more thoroughly rinsed before loading.

Operation of your dishwasher is programmed by a timer. There may be many combinations of time and cycles, with or without automatic detergent and wetting agent dispensers. At each cycle the machine must fill, run, drain, rinse and dry.

Your Owner's Manual will contain specific information about the operational cycles of your particular machine. Most dishwashers include a wiring diagram and cycle

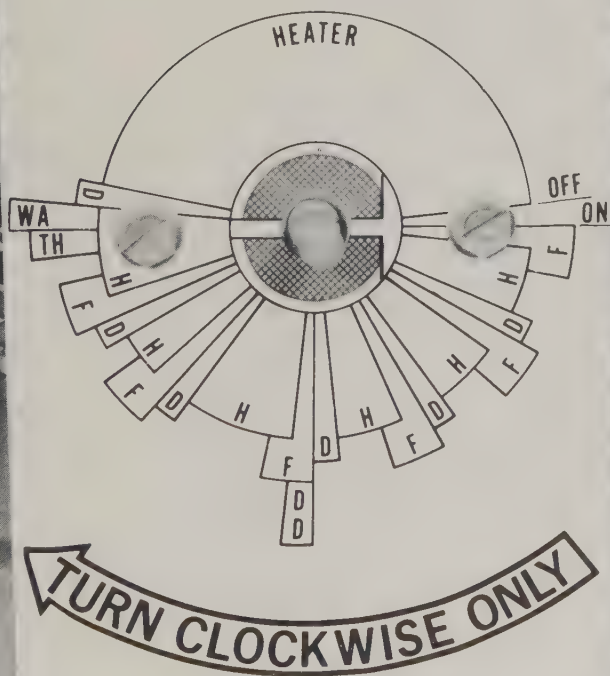


▲ Parts location of a typical impeller-type dishwasher.

DISCONNECT FROM ELECTRICAL
SUPPLY BEFORE SERVICING UNIT.

F — FILL VALVE	DD — DET. DISP.
H — HEATER	TH — THERMOSTAT
D — DRAIN	WA — WET. AGT.

See Wiring Diagram Label (Console Back)
Component Activity Varies With Cycle



▲ The timer can be advanced manually to any part of the cycle. The label is coded to show the active components.

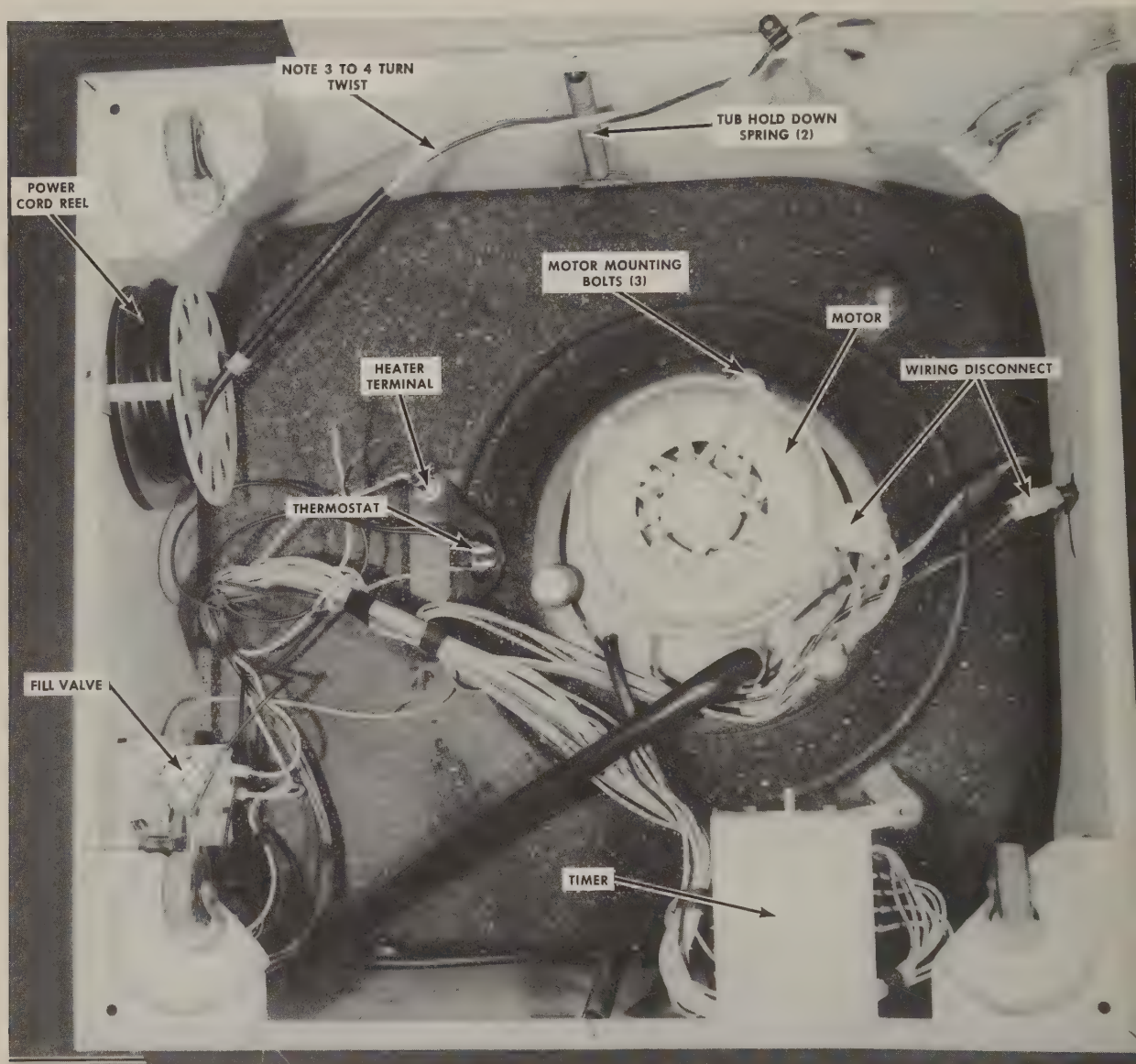


chart pasted on the back or inside the access panel. This information will include the sequence of cycles and the length of time each one will require.

Up to now we have discussed the sources and resolutions of about 75% of dishwasher problems. Other failures will probably be mechanical.

Finding the problem. If your dishwasher is portable, remove the back to get at the

▲ Location of major components of a portable dishwasher. Some machines have timer mounted in an upper console.

working parts. If it is an undercounter machine, remove the access panel which is located under the door; or you may have to lay the machine on the floor in order to gain entry.

Much can be discovered by careful ob-

How to Repair Your Dishwasher

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ervation. Leaks, rust, physical damage and obviously burned parts will be clearly seen. Unusual noises, smells, squeaks, and/or rattles should be tracked down and eliminated before they develop into serious trouble.

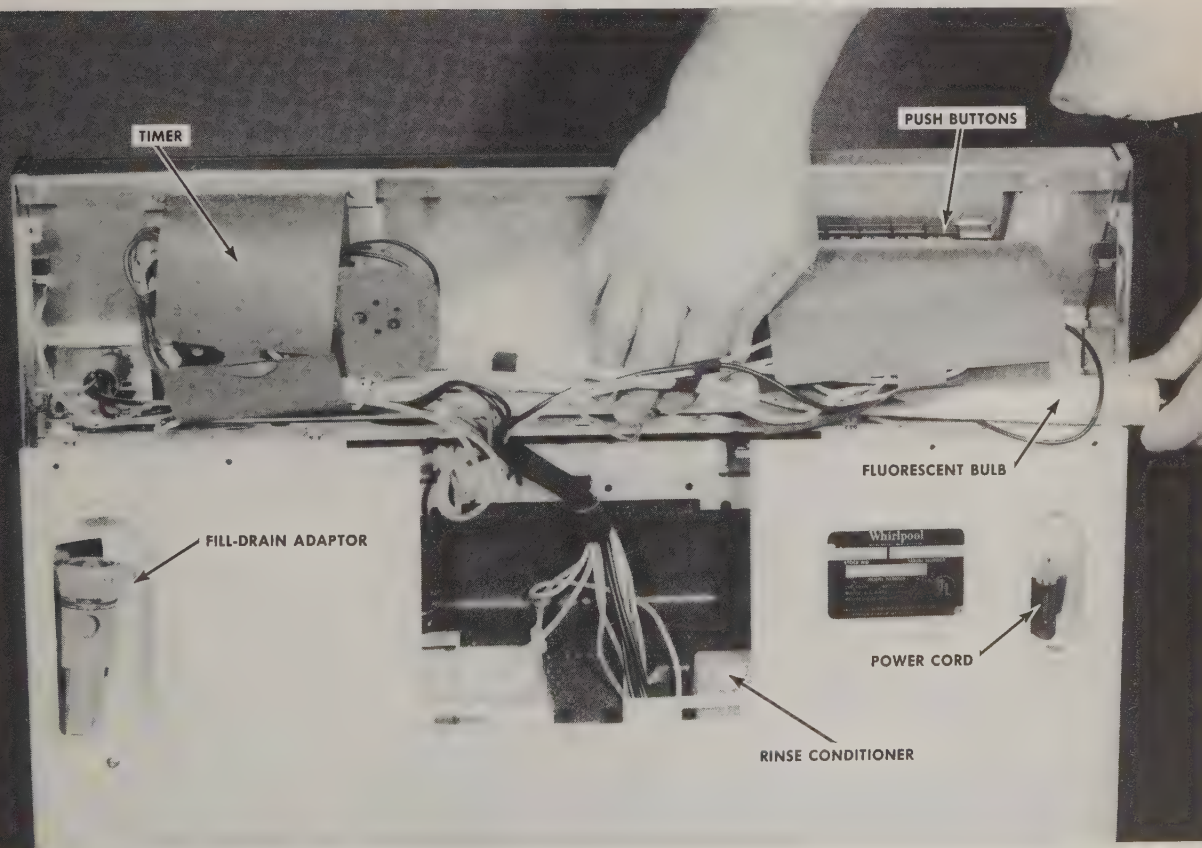
All water inlet valves have a fine mesh screen to prevent specks of foreign matter from entering the valve. If this becomes clogged it will restrict the water flow. On portable dishwashers using the nylon bodied valve, the screen is accessible by removing the inlet hose connection and extracting the screen with tweezers or needle-nosed pliers. The screen can then be cleaned and put back—or replaced if cleaning doesn't seem to work.

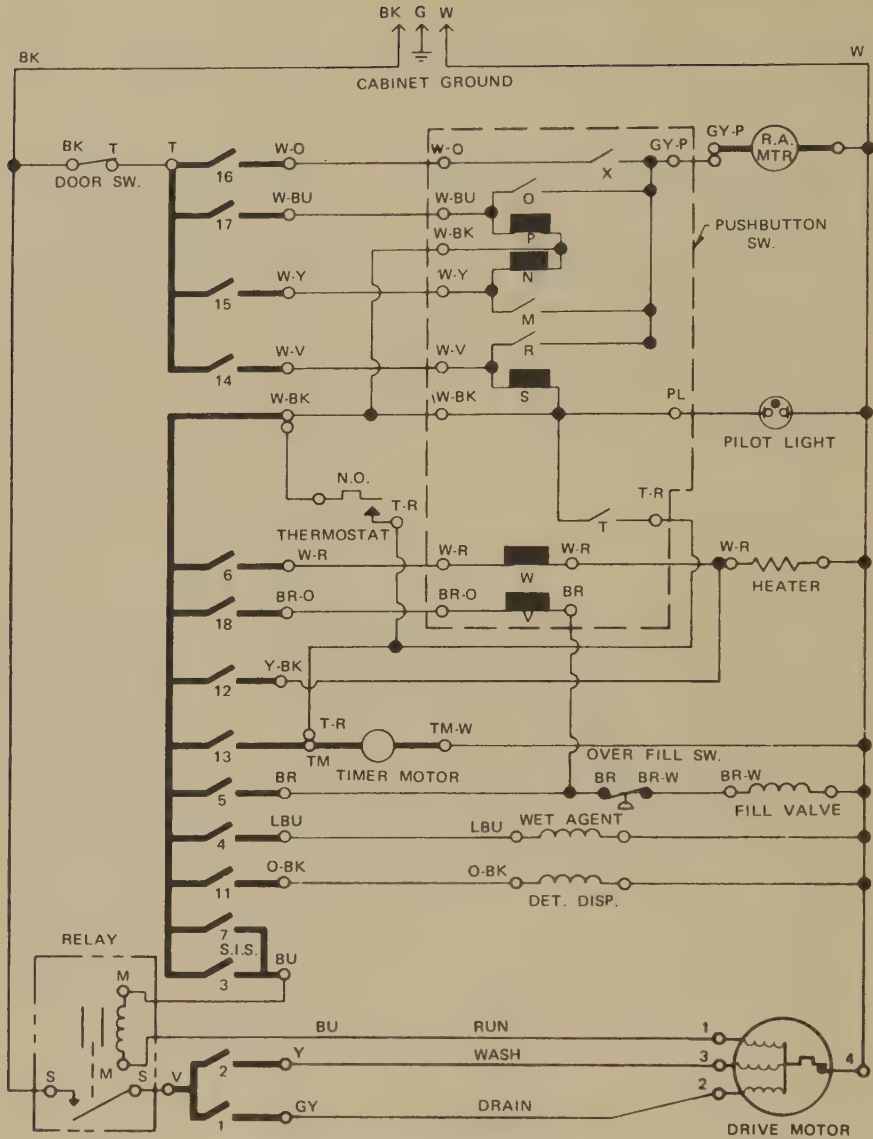
▼ *Rear view of the control console of a portable dishwasher with inspection panels removed.*

Built-in machines use a brass bodied valve. The strainer is removed for cleaning by unscrewing the large box cap nut on the underside of the valve. Make sure the water supply is turned off or you'll have a flood!

The drain for portable dishwashers is a hose that empties into the sink. Built-in machines require proper connection to the household plumbing system. Both machines must have the drain line rising from the machine at least 30 inches to prevent water from flowing out of the machine by the force of gravity. Make certain there are no kinks or foreign matter in this drain hose that will obstruct the water flow.

A drain pump can get jammed with heavy food particles, toothpicks, small pieces of bone, etc. The symptom of a jammed pump is water not draining from



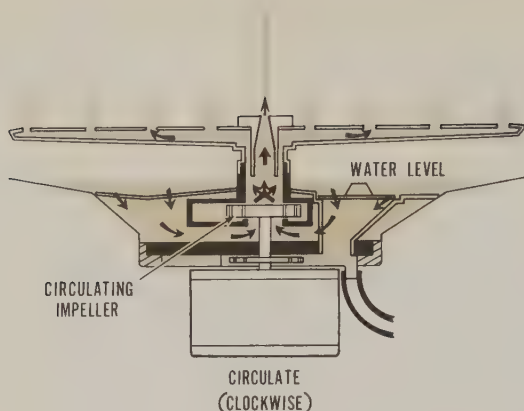


the machine. The offending particle will have to be removed.

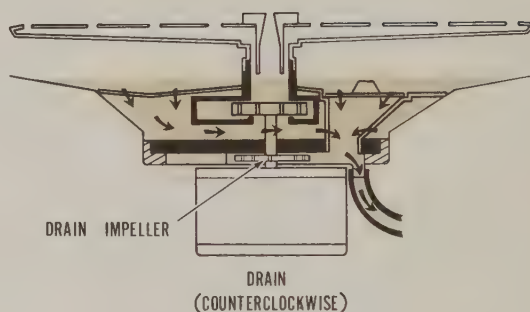
To remove the drain pump from your machine disconnect the two wires, two hoses (catch what water is still in the hoses in a shallow pan), and remove the mounting

▲ Wiring diagram for a typical dishwasher with a reversing motor. The motor operates the recirculating pump in the wash direction and the drain pump in the opposite direction. The timer determines which start winding is used. The starting relay is operated by the current flow to the run winding, and automatically disconnects the start winding when the motor reaches its proper running speed.

NOTE 4: ACTIVE CIRCUITS COLUMN REFERS TO ENCIRCLED NUMBERS ON DIAGRAM.



▲ When motor runs clockwise, it drives the impeller to circulate water within the dishwasher. The center vertical stream impinges on the upper spray arm for distribution to the dishes on upper rack. When the motor turns counterclockwise, the drain impeller pumps water out of the machine. ➤



screws. To clean the pump remove the four Phillips head screws and pull off the pump body. This will expose the impeller and any foreign matter that may have collected there.

Mark the location of the discharge outlet with respect to the mounting frame so that, when it is reassembled, the outlet will be in its correct position to line up with its hose.

Some models use the same motor for pump out as for washing by reversing the motor's direction of rotation. This motor reversal is controlled by switching within the timer. So, if the motor fails to reverse, either from wash to pump out, or pump out to wash, replace the timer. Do not blame the motor! If this motor fails to start check its starting relay.

By following the wiring diagram and by

using a test light or a continuity tester, any electrical part or circuit can be checked out. When using a test light be careful because the current is on. Use the test light to determine whether electricity is reaching the working part. If the bulb lights and the part doesn't function, then trouble is in the part. (Working parts for a dishwasher are: motors, fill valve, heater, and dispensing solenoids.) If the bulb does not light the trouble may be a loose connection or a defective timer switch. The wiring diagram and operations chart on your machine will tell you which circuits are supposed to be active at any given time.

Before condemning any working part or the timer, make sure that there is power in the machine and that the door lid switch is sound.

See also: APPLIANCE REPAIR; ELECTRICITY.

Safe Storage for Your Sporting Equipment

This easy-to-build cabinet is perfect for guns, trophies, or anything you wish to display

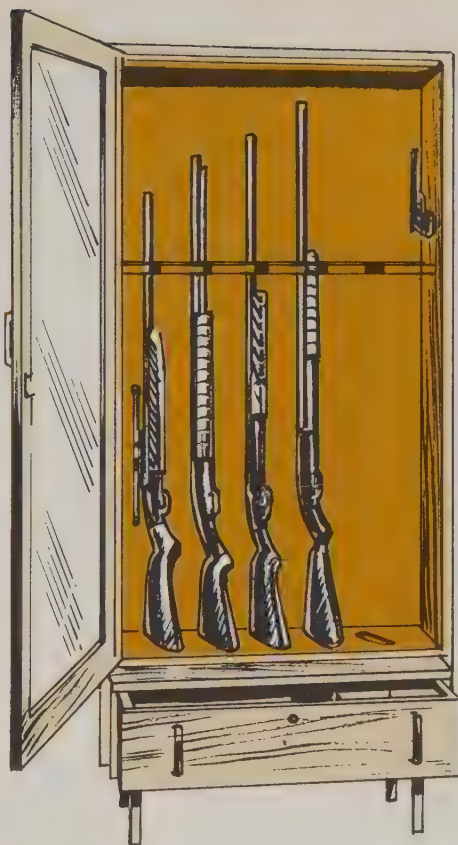
HERE IS A GUN CABINET you will be proud of as a piece of furniture. It is a handsome way to display your guns, as well as providing locked storage for your ammunition. It is also one of the safest ways to keep guns away from children.

The gun cabinet is easy to build using a circular power saw but will require considerable skill if you plan to use a hand saw. The cabinet shown here was made from one sheet of $\frac{3}{4}$ -inch lumber-core, white ash plywood. If desired, you can use 1-inch stock lumber except for the back panel.

Although the cabinet was designed primarily for guns, with a few interior changes it becomes a model display case, fishing cabinet, or combination hunting-fishing unit.

Obtain all the materials specified in the Materials List except the glass. Saw out the various panels from the $\frac{3}{4}$ -inch plywood to dimensions.

Saw rabbets in the ends of panels with dado blades or two cuts using a planer blade in your circular saw. Also rabbet back edges of the outer cabinet panels to fit



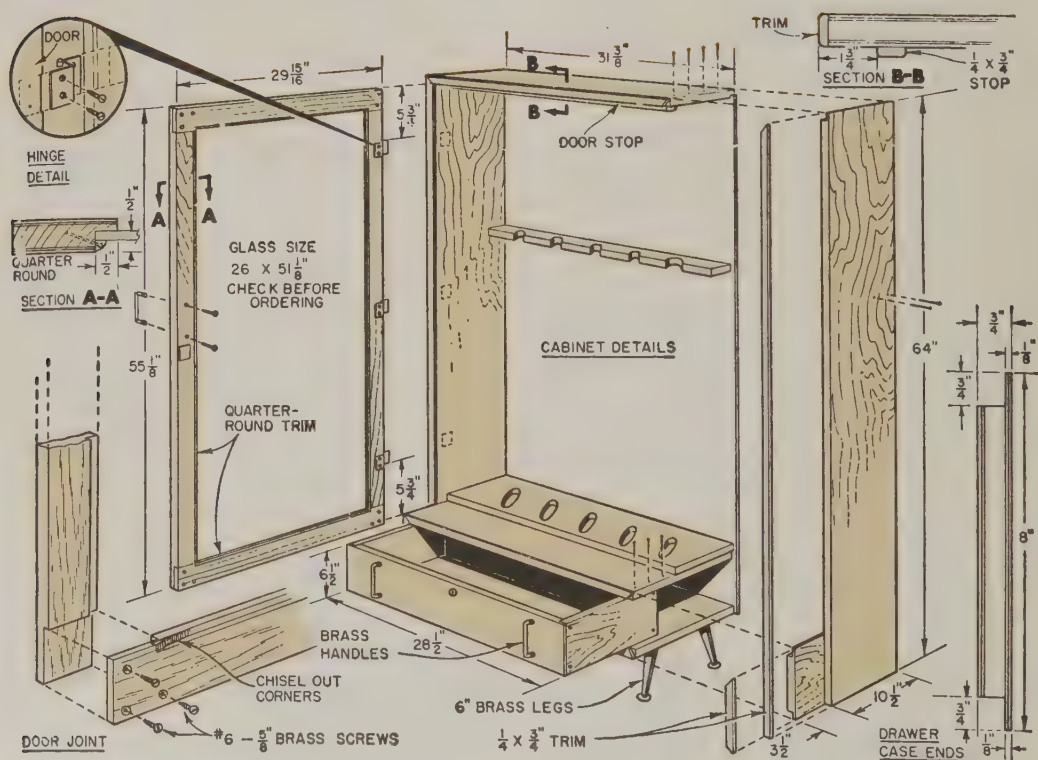
▲ Showcase gun rack made of hardwood plywood is a useful addition to any den or game room. Finish to blend with other furniture.

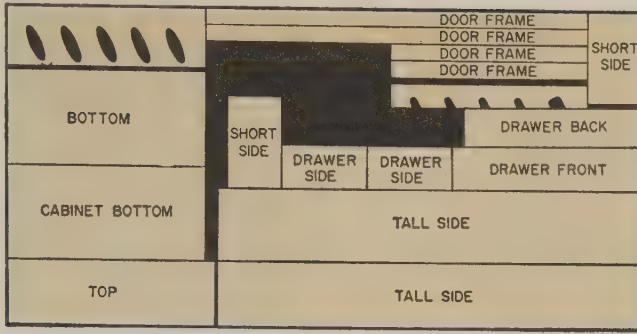
the $\frac{1}{4}$ -inch back panel, and side panels, of the drawer case for the bottom and shelf panels. Rabbeting in this way allows maximum support with minimum end grain showing. Edges will be covered later with matching trim strips mitered at the corners.

Screw-fasten end panels of the drawer case to the tall cabinet side panels so the bottom edges are flush and the rear edge of the drawer case is flush with the back rabbet of the side panels. Screw from the inside out, using five #10 x $1\frac{1}{4}$ -inch flat head screws on each end, after drilling pilot and clearance holes and countersinking for each screw.

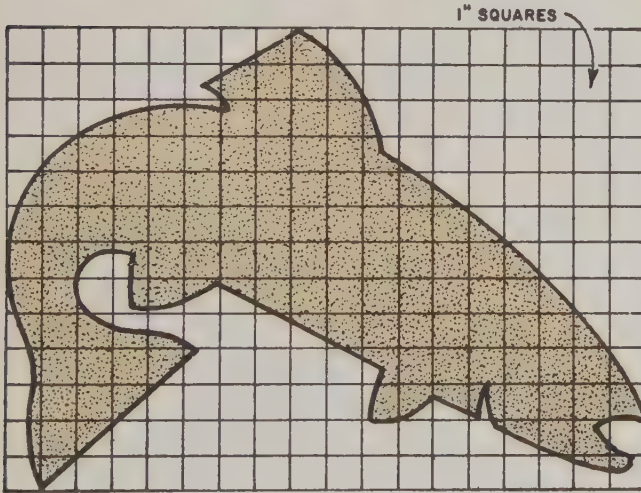
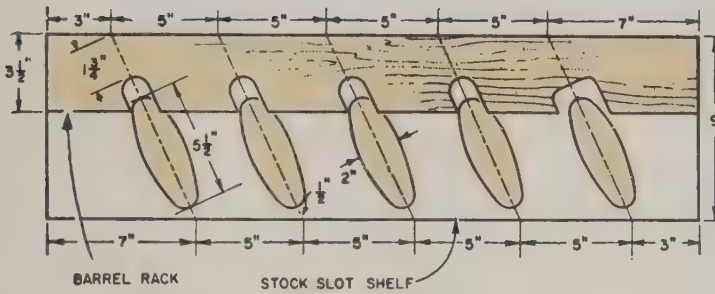
Install the drawer case bottom and top

display cabinet, corner: see cabinets
divider: see room divider
divider unit: see storage
diving: see swimming
diving, scuba: see scuba diving

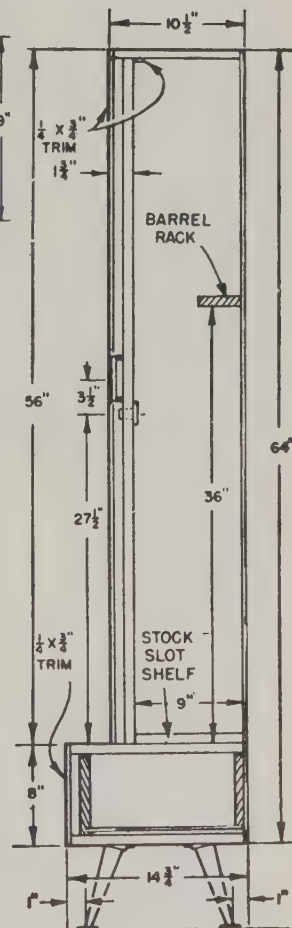




CUTTING DIAGRAM FOR $\frac{3}{4}$ " X 4' X 8' PLYWOOD



CORK PANEL LAYOUT

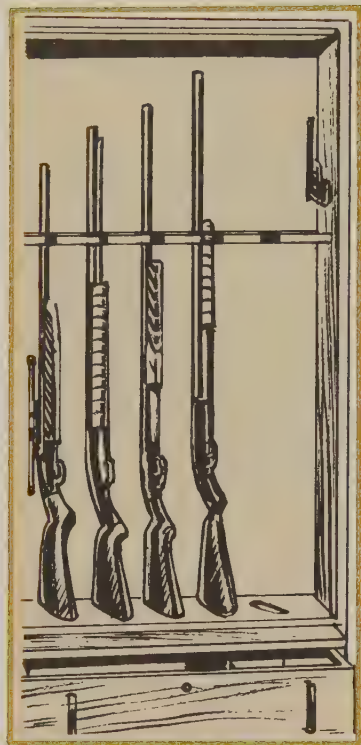


PROFILE SECTION

panels with glue and the same size screws so that both are flush with the back rabbet of the drawer case side panels. Screws through top of panel of the drawer case should be placed far enough back so that the stock slot shelf will cover them. Use 6d finishing nails at the front edge. Attach cab-

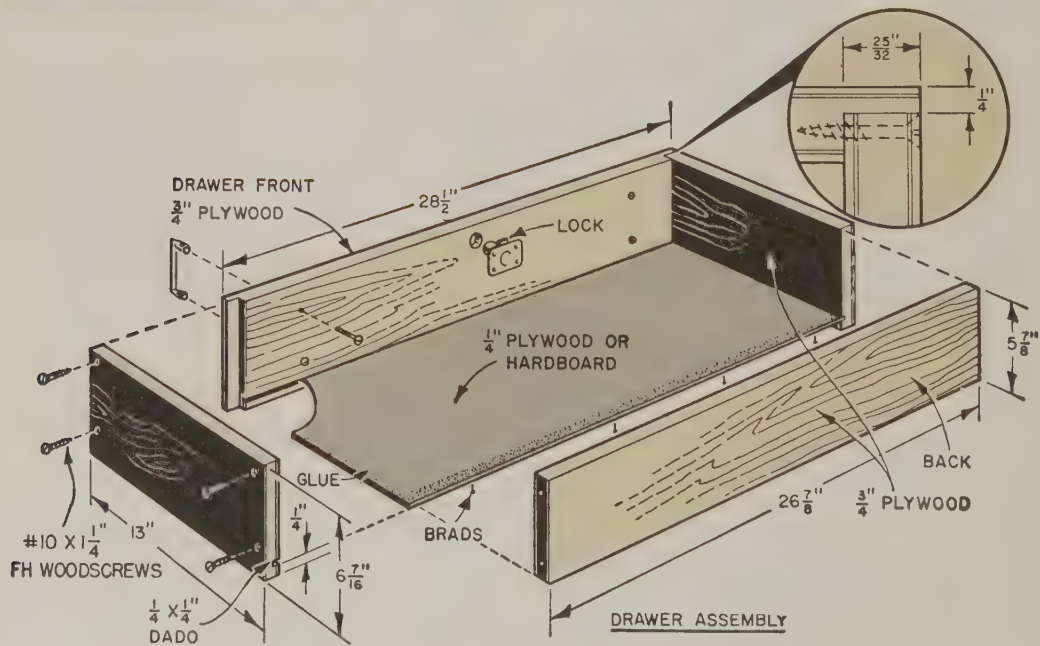
inet top similarly with 6d finishing nails and glue.

Cut a 31 x 64-inch piece of plywood for the back so it will just fit into the side back



▲ Large drawer stores heavy equipment.

◀ Cabinet sides offer display space for several pistols hung on slanted dowels cut from matching hardwood.



Safe Storage for Your Sporting Equipment

rabbets and be flush with the bottom of the drawer case. Fasten this back panel well in place with glue and lath nails. It will square and stiffen the cabinet against racking.

To make the door frame, rip the $\frac{3}{4}$ x $2\frac{1}{2}$ -inch door frame pieces, then cut $\frac{1}{2}$ -inch-square rabbets in all four sides to take the glass and saw or rout half laps for corner joints. Use three #6 x $\frac{5}{8}$ -inch brass screws and glue to hold each corner.

After the door frame is completed, hang it on three cabinet offset hinges. Fit door so that it clears cabinet the thickness of a dime on all sides. Brad in trim for a door stop.

Now you can measure the opening, buy the glass and install it with $\frac{1}{4}$ -inch quarter-round molding.

Make the drawer by rabbeting and dadoing the front sides. Assemble with glue and screw ends to front and rear sides, after drilling $\frac{3}{16}$ -inch shank holes and $\frac{1}{8}$ -inch pilot holes. For the 12 x 28-inch bottom use $\frac{1}{4}$ -inch plywood or tempered hardboard. Install the drawer lock and cabinet handles.

Saw the barrel rack and stock slot shelf from $\frac{3}{4}$ -inch plywood. Form the slots in both boards; first by drilling 1-inch holes at the slot ends, then sawing out the excess with a coping saw or jig saw. Line slots with dark brown felt to protect the barrels.

Glue and nail the shelves in place using 4d finishing nails through the back and sides.

To add pistol pegs to the cabinet, drill $\frac{1}{4}$ -inch holes in side panels at a 5° to 10° angle for 2-inch-long dowels of matching wood.

If you plan to use the cabinet for a fishing or trophy cabinet, tailor the shelves to suit your needs from $\frac{3}{4}$ -inch plywood or 1-inch lumber. For photos or lures, glue a cork panel to part of the rear wall. For special shape panels prepare a template on paper or cardboard, using 1-inch squares.

Trim the edges of the plywood with $\frac{1}{4}$ x $\frac{3}{4}$ -inch strips of the same type wood as the plywood. Add the locks and handles, attaching them from the back sides of door and drawer.

Screw-fasten the legs in place 3 inches from the sides so that they are parallel to the sides. Locate the feet or ferrules about 1 inch from a plumb line dropped from front and back of the cabinet.

The work done, finish the cabinet with spar varnish. You might prefer to match yours with the wood trim.

Unfamiliar hands with access to an unlocked gun cabinet can be more dangerous than an armed burglar. So keep your cabinet locked—and carry the key with you.

See also: FURNITURE, INDOOR; WOODWORKING.

MATERIALS LIST

Quantity	Size and Description	Purpose
1	$\frac{3}{4}$ " 4'x8' lumber core hardwood plywood	cabinet and drawer
1	$\frac{1}{4}$ " 4'x8' matching plywood	back and drawer bottom
4	$\frac{1}{4}$ " $\frac{3}{4}$ "x6' hardwood strip	cabinet edge trim and door stop
2	$\frac{1}{4}$ "x8' quarter-round molding	glass stop
4	6" brass tapered legs	
as needed	#10x1 $\frac{1}{4}$ " flat head wood screws	
as needed	#6x $\frac{5}{8}$ " flat head brass screws	

NOTE: Also need finishing nails, lath nails, brads, screws, glue, brass offset cabinet hinges, brass handles, brass cabinet lock, double-strength glass and heavy felt.

➤ Tie up along a bulkhead with long mooring lines, allowing the craft to edge in while the engines are left in neutral.



The Techniques of Docking Your Boat

A little practice makes the difference between a gentle bump and a bashed-in bow

ANYBODY CAN HANDLE A BOAT on the open water. When it is calm enough, you can put a young child at the wheel several miles offshore without fearing a collision. It is at dockside that the trouble starts!

In most states, you cannot drive an automobile without passing a basic test. On most waterways, a small percentage of the helmsmen afloat should have been grounded before they cast loose the mooring lines. Inexperience and carelessness probably cause 90 percent of the dents and abrasions you will find on outboard hulls.

The perennial jokes about women drivers denting fenders can be applied afloat as well as ashore. But it is certainly not only the girls. Men and boys forget that a skiff does not come equipped with brakes. You

cannot recall the effects of wind and tide on a skiff or cruiser as you are pushed broadside against a pier. You should build a mental picture of the forces tugging at your boat *before* the physical actuality.

When the man at the wheel knows what is going to happen, he knows what precautions to take. A helmsman worth his salt carries a whole series of mental pictures in his head. As he assesses the problem looming under the keel, an automatic slide projector clicks topside and he reacts at the controls.

Sometimes it is a conscious combination of action and reaction. Generally, this type of sailor is relatively new on the water and has made it his business to attend a seamanship course or read a few nautical primers. Often it is a subconscious reflex—an “old timer’s” system based on reflexes alone.

Pulling out of a crowded pier with a single-engine cruiser several years ago, a passenger was asked to cast loose the lines. In error, a loop on the starboard spring was left around a piling. As the boat backed

from the slip, the rope end jammed under a neighbor's rig. *No matter how the wheel was turned, or the throttle handled, the hull kept broaching in the slip!*

There was an oldtime bayman abroad. First he reached forward and switched off the ignition key. Then he walked aft with a fender and placed that bumper between the boats. In a matter of minutes, the offending rope was unsnarled and we were underway unscathed.

Try learning as you sail. Absorb basic theory through the printed word. Then, after you have learned enough to understand the boat's movement on paper go afloat.

Weight distribution and balance are prime factors in the way your boat handles. With two people sitting forward in a small outboard pram, it will run nose down and pivot on the bow while turning. With the same two passengers aft, the boat will pivot amidships. Thus you can change a boat's steering characteristics by adjusting her trim.

Try the identical experiment on a cruiser weighing several thousand pounds. You will note that weight distribution changes the center of gravity far less. The big boat handles about the same either way.

Therefore, you can put one of the new fiberglass tanks under the forward deck of a twenty-footer without radically changing the boat's helm. Try the same maneuver with a fourteen-footer and it will probably handle like a waterlogged chunk of drift wood. Balance the tank amidships under the wheel and the results will likely be satisfactory.

Suppose you are making a port landing on a parallel pier with a single screw outboard. It is best to make the approach on a twenty- to thirty-degree angle. In the event that you are squeezed tightly for space, make the angle still sharper in order to avoid damage to other boats in case of trouble.

Do not come in fast and count on using the reverse gear as a brake! That's a nautical cowboy tactic which will eventually gain you a smashed bow along with a couple of lawsuits. Crack your throttle slow ahead, shifting the motor back into neutral each time it makes much headway.

You should be able to stop dead in the water so a crewman on the bow can step onto the dock and place a mooring line ashore. Standing on the deck, your mate might try to drop a loop of line around a deck bollard. If he cannot, back off and try it over again until he can.

Allow several feet of slack line on the single strand that is secured ashore. Put a few turns around your bow bitt. Run ahead slowly until the line comes taut. By turning the wheel slightly offshore, you can make the stern swing into the dock. Swinging the wheel inshore will make bow come in first.

The standard procedure in the maneuver described above is to keep the vessel's port side to the pier or landing. This works ideally with the wind and current under the bow. Unfortunately, the current's liable to be astern and the wind coming in from offshore, blowing the hull against the dock.

Here is where mental pictures come in handy. Figure out which factor affects you more; wind or tide. For our example, assume it is a gusty, blustering breeze.

Reverse your method of approach so your bow meets the current. Nose into the upstream part of your berth on an acute angle so the wind catches only your stern rather than the full length of the boat's side. Place a bowline ashore, keeping the motor idling in reverse so the boat will not blow against the dock. Once the rope is secured, back off until it comes taut and turn the wheel upstream. With fenders out, let the wind hit your port side and blow you into the mooring.

Though it might sound like an art requiring years of practice, helmsmanship is really nothing more than common sense.

Nobody expects you to bring an ocean liner into a wharf against a ten-knot current. You will probably be in protected water with a single or twin-engine outboard stern-drive or inboard not exceeding twenty-six feet in length. Frankly, it is easier than driving a car.

Try taking the boat close to a stake or buoy somewhere offshore, far from the dock. Out there with nobody watching critically and nothing to make anyone nervous, practice making approaches on the stake. Imagine it is a parallel pier or entryway to a slip.

As you make approaches, you will learn the "feel" of your hull. You will know how far it shoots forward after the gears have been shifted back into neutral. You will be able to estimate its turning circle and know the amount of space that is required for safe navigation.

Try dropping a cushion or life preserver overboard. Swing wide and make a three hundred and sixty-degree turn so you can reach down and pick it up effortlessly. When you can do that every time, you're getting to know the boat.

A dual motor installation is far simpler to maneuver than a single engine. You have the increased aid of being able to run one forward while the other is reversed, thus spinning on a dime.

Coming into the identical parallel dock discussed previously, throw the inside engine into neutral and use only the outside motor. The propeller farthest from the dock will be least affected by eddy currents and backlash effects bouncing off the pier. Thus, as a simple rule of thumb, begin calmly with one engine rather than frantically trying to handle two.

Always start slowly. Making a mistake at a crawl will not cause a catastrophe. The identical error with your engines revved up can cause physical as well as property damage.

Boats at rest tend to remain at rest while

The Techniques of Docking Your Boat

boats in motion keep coming—long after you have taken them out of gear. Physicists can give you fancy formulas to calculate precisely how far a hull will travel. Handling the wheel, all you really need is common sense.

An outboard or inboard-outboard carrying a large, heavy propeller is a hard boat to stop when traveling through the water. Once you advance the throttle and push out a considerable current flow under the transom, it behaves more like a battleship than a cockleshell.

Conversely, a smaller high-speed propeller will kick a boat sideways without appreciably pushing her forward. You can make maneuvers with a lightweight skiff that cannot be duplicated with a decked-in runabout. It is like making a U-turn in a driveway with a sports car and then trying it with a limousine. Though it works with the one, it is impossible with the other.

You must know your boat. Handling it under various wind and sea conditions will soon tell you the necessary answers. Shifting the controls is soon done by "touch" without the necessity of looking down.

Remember that leaving a pier is an easier process than docking. In many cases; you drift away after dropping the lines. Where it is necessary to force the hull away from the dock, it is usually accomplished by backing and/or using a spring line.

With the port side against a parallel dock, drop all the lines except an after bow spring. Proceed ahead against the tension of the line, swinging the wheel towards the dock to throw the stern offshore. Lift the line abroad and simply back into the stream.

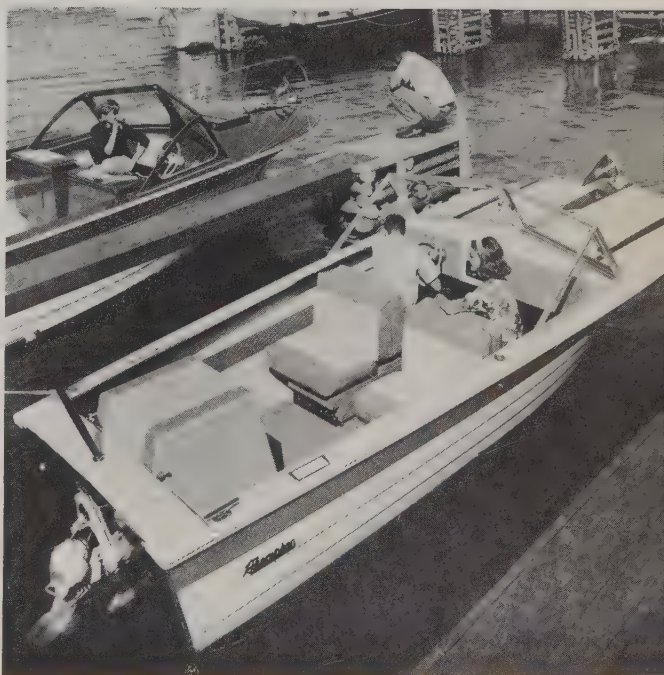
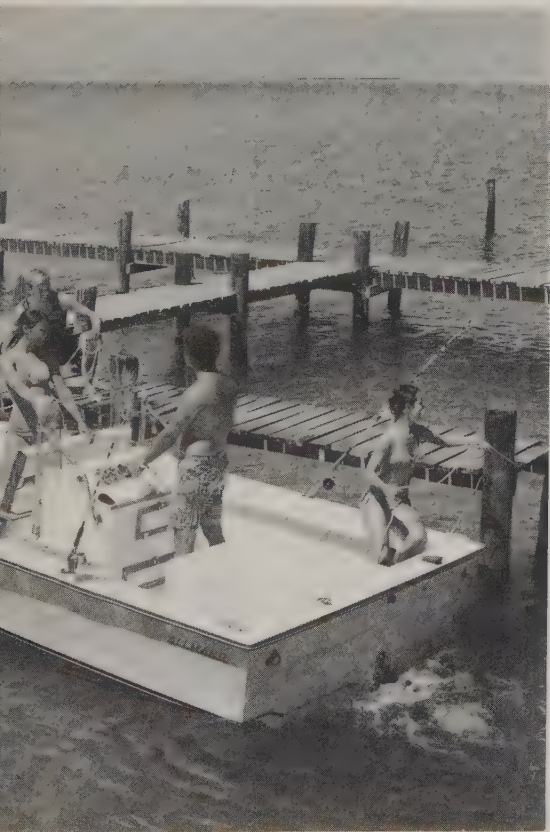
In the initial phases of these maneuvers, it might be a wise idea to put a stout fender across the bow. You will have an increased sense of confidence if you can nose up against a dock or piling with chafing gear between you and the shore.

With the wind blowing off the pier, slack



◀ Slow speeds and planning provide answers to most problems of docking. If you are ashore, volunteer help with the lines; someday you may need help.

▼ Positioning crew with lines and fenders before approaching dock helps the skipper to keep control.

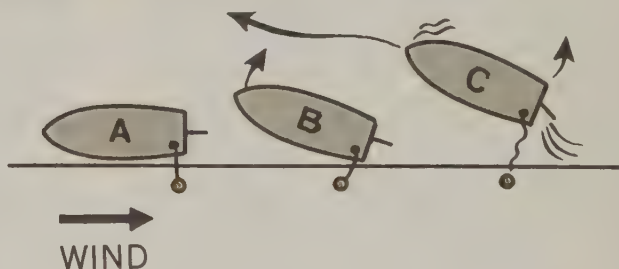


▲ Crowded dock space will not prevent you from tying up if you use bow and stern lines to hold the craft off the pilings. Boat can be safely secured against currents, in non-tidal waters.

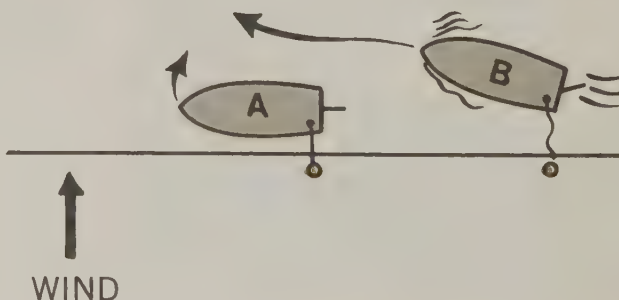


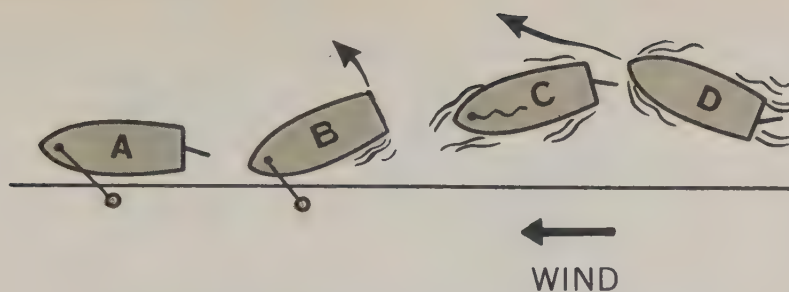
◀ Passing gear into the boat from the dock instead of trying to climb aboard with equipment in hand will increase your measure of safety at the dock.

➤ Leaving a dock, boat alongside dock, wind ahead: A. Single up to one stern line, no power, no rudder. B. Let wind swing bow out, or push bow out with boat hook. C. With bow out 15 or 20 degrees, swing stern clear by using hard left rudder (right rudder if dock is to starboard) and brief spurts of power. Let stern line go when boat is a few feet from the dock, and go ahead slowly. Steer away from dock with slight rudder.

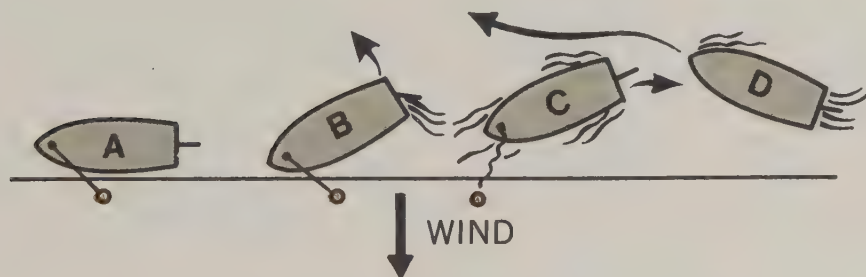


➤ Leaving a dock, boat alongside dock, wind off the dock: A. Single up to one stern line and let the wind swing the bow out. B. Ease off on the stern line until clear of the dock. Let go the line, and go ahead slowly. Steer away from the dock with slight rudder.

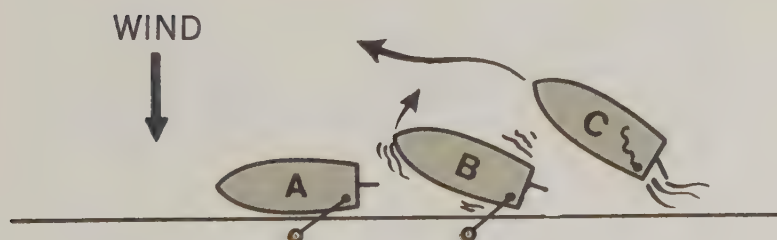




▲ Leaving a dock, boat alongside dock, wind astern: A. Single up to bow spring line. B. Let wind swing the stern out or use the engine in brief spurts with hard left rudder (right rudder if moored starboard side to dock). C. Reverse engine and back off slowly; cast off line. D. When well clear of dock, go ahead slowly and use slight rudder to steer away from the dock.



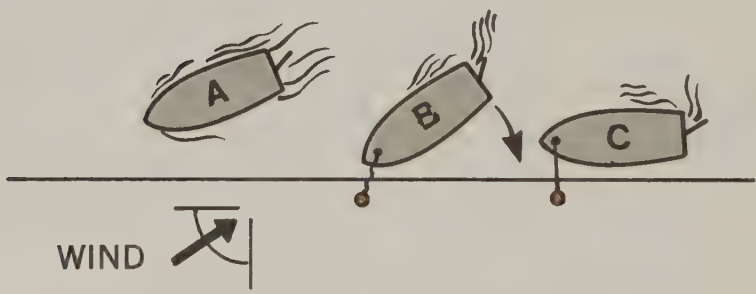
▲ Leaving a dock, boat alongside dock, wind on the dock: A. Single up to bow spring line led well aft. B. Use spurts of power ahead to bring stern out, using hard left rudder (right rudder if dock is to starboard). C. Use engine in reverse to back away from dock, cast off bow spring. D. When well clear, go ahead with engine, and steer clear of the dock.



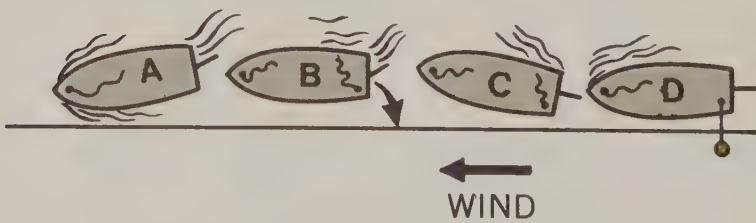
▲ Leaving a dock, boat alongside dock, wind on the dock: A. Single up to single stern spring line. B. Use half to full power astern to swing bow out, no rudder. C. Use rudder half left (half right if dock is to starboard) and engine slow ahead to bring stern out. Cast off line, and go ahead slowly using slight rudder to steer clear of dock.



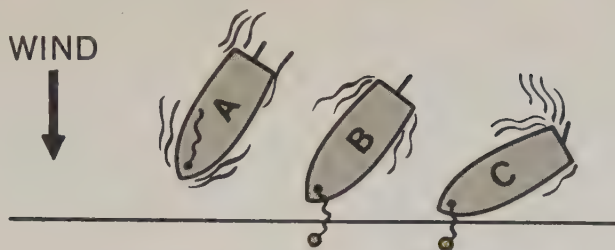
▲ Leaving a slip: A. Single up to single stern line, long enough to reach from stern cleat to a point forward about 2/3 the length of the boat. Make outboard end of line fast to outer end of the slip. B. Go astern slowly until line is taut, then swing rudder hard left. Boat's stern will swing to port under full control. C. Cast off when clear, go ahead, give a slight kick of left rudder to swing stern out, then use slight right rudder to steer clear.



▲ Docking, wind off the dock or ahead: A. Approach slowly at an angle of 30 to 40 degrees to the dock. B. Put engine in reverse to halt boat with bow about one foot from dock, get bow line ashore. C. With hard right rudder, use spurts of power ahead to bring stern in to dock. C. Tie up.

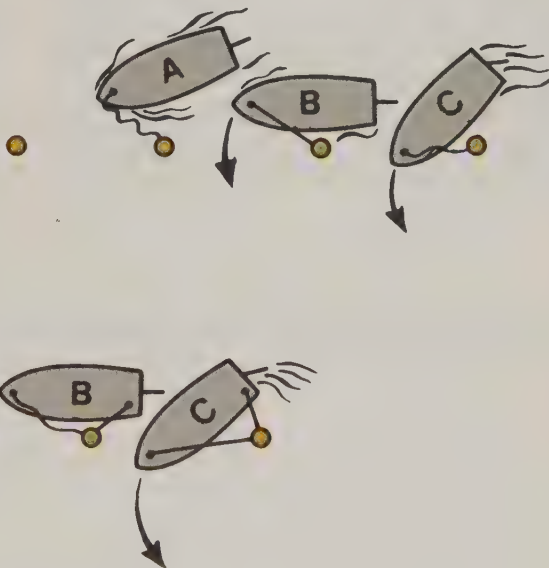


▲ Docking, wind astern: A. Approach closely to dock, at an angle of 10 to 15 degrees. B. When one or two feet from dock, use right rudder and brief spurt of power to start stern swinging toward dock. C. As soon as stern starts to swing in (boat parallel to dock), reverse engine to stop boat. D. Get stern line ashore, and let wind bring bow in to dock. Tie up.



▲ Docking, wind on the dock: A. Approach at a steep angle of about 60 to 80 degrees. B. Reverse engine to stop boat about a foot from dock; ease boat off with boat hook if possible; get bow line ashore. C. Let wind bring stern in, using engine in reverse and hard right rudder for braking action. Tie up.

➤ Entering a slip, wind anywhere but astern: A. Approach slowly, roughly parallel to end of slip. Pass a line to the pile or cleat nearest your approach. B. Reverse engine to slow the approach and stop the boat just short of the far piling, with the line taut. C. Put rudder hard left and use spurt of power to swing boat into slip, using the pile as a pivot. Ease into slip and tie up.



▲ Entering a slip, wind astern: A. Approach as above, but use enough power to stop boat completely after passing the bow line. B. Pass a stern line to the same pile or cleat. C. Haul both lines taut and use engine, wind, and rudder to ease boat around and into the slip. Tie up.

the lines slowly and ease away naturally. With the wind blowing against the dock, go ahead on an after bow spring till the stern is well out, then cast off and put the engines in full reverse.

With the current coming from astern,

hold the after bow spring and ease off on the stern line until the transom is carried outward. When you are clear, back away. To clear a dock with the current against you, use a forward quarter spring under slight strain to force the stern in and the

bow under the current. Again, wait until you are well clear before getting underway.

Your boat steers from the transom and not the bow. Each time you swing the wheel to the left, the bow turns to port but *the stern shifts to starboard!* Thus it is necessary to be well clear of any obstruction before feeding the engine power.

A landlubber could not comprehend this problem and damaged his boat. He let the bow drift off the dock, then dropped the lines and gunned her ahead while swinging the wheel offshore. The stern came in and smashed against the dock, ricocheting off again. In turn, this pulled the bow closer.

He tried it again, and bounced off the dock again. Careening off a stern drive rig ahead of him (while the frustrated owner watched helplessly), he finally reached the channel. Without a backward glance, he proceeded out into the bay, unaware that the county police boat had already been dispatched in pursuit.

You should check with the United States

The Techniques of Docking Your Boat

Power Squadron and attend one of their seamanship courses if it can be done conveniently. Independently, or in addition to that, read *Piloting Seamanship and Small Boat Handling* by Charles F. Chapman or any other recognized blue water reference book.

When you are at the controls of your outboard, you are the boss. If you order the lines dropped, it should be done without argument or discussion from the cockpit. If you bounce the hull against a piling like a Mexican jumping bean, it is your responsibility.

The proof of your seamanship lies in your handling dockside. Bring her in to a slip "feather-light" every time and you are well on the road to becoming a master mariner. Learn to handle an outboard competently. The identical principles apply to anything from a ferry to an aircraft carrier.

See also: BOAT HANDLING; BOATING.

RECOMMENDED PERMANENT MOORINGS FOR WINDS UP TO 75 MPH										
Boat Length Overall	Mushroom Anchor (Min. Wt.)	Heavy Chain		Light Chain		Length (Minim.) (Feet)	Pennant			Total Scope (Chocks to Mushroom) (Feet)
		Length (Feet)	Diameter (Inches)	Length (Feet)	Diameter (Inches)		Diameter (Inches)		Stainless Steel	
							Manila	Nylon		
MOTOR BOATS										
25	225	30	7/8	20	3/8	20	1	7/8	3/32	70
35	300	35	1	20	3/8	20	1 1/4	1	1 1/32	75
45	400	40	1	20	1/2	20	1 1/2	1 1/4	3/8	80
55	500	50	1	20	3/8	20	2	1 1/2	3/16	90
RACING TYPE SAILBOATS										
25	125	30	5/8	20	3/8	20	1	7/8	3/32	70
35	200	30	3/4	20	3/8	20	1 1/4	1	1 1/32	70
45	325	35	1	20	3/8	20	1 1/2	1 1/4	3/8	75
55	450	45	1	20	3/8	20	2	1 1/2	3/16	85
CRUISING TYPE SAILBOATS										
25	175	30	3/4	20	3/8	20	1	7/8	3/32	70
35	250	30	1	20	3/8	20	1 1/4	1	1 1/32	70
45	400	40	1	20	3/8	20	1 1/2	1 1/4	3/8	80
55	550	55	1	20	3/8	20	2	1 1/2	3/16	95

Change the Sound of Your Front Door

With the easy installation of door chimes, you can fill your home with pleasant tones and make an attractive addition to your present decor

NO MATTER HOW tolerant you have become toward your antiquated doorbell, the tones of a modern chime will bring a new kind of serenity to your home. More than that, the chime will add a touch of decorative elegance to please the eye as well as the ear.

If you already have a pretty good chime, there may still be questions to ask. For example, can it be heard throughout the house—or should you have another extension chime in a wing of the house or perhaps in the basement? Do you have good signals for *all* doors? What would be the advantages of incorporating the door chimes with a radio-intercom system?

Whatever your needs may be, there is bound to be a chime that is just right. Simple ones cost no more than a couple of movie tickets. More costly chimes can play as many as eight notes. Some chimes double as wall clocks or as elegant foyer lights. Some are unmistakably chimes by virtue of their gleaming metal tubes, while others reveal no tubes. The exterior de-



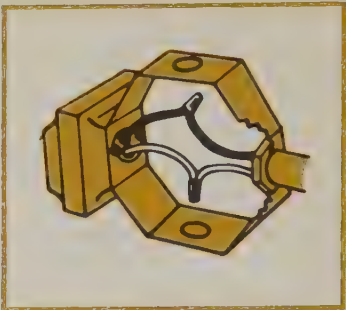
signs—ranging from simulated spice cabinets to heraldic shields—match any decor and please every taste. Most chimes operate by means of a simple solenoid action, some multi-tone chimes are motor driven, a few feature solid-state electronic circuitry, and some are entirely non-electric.

Chimes come with wiring diagrams and instructions. The diagrams shown here, which relate to one company's equipment, are typical of most chimes; they will help you anticipate, in advance, the wiring problems you might encounter with any given type of chime system.

In early days, doorbells were powered by dry cells. Now low-voltage step-down transformers are used to convert 110-volt house current to the required 10 to 16 volts. Choose your transformer only after selecting your chime to be sure that it provides enough power to operate the chime properly. Some chimes come with matching transformers.

A 10-volt, 5-watt transformer of the type used with doorbells and buzzers can oper-

➤ Mount transformer to junction or panel box, connect to the house circuit. Connect black wire to black, white wire to white.

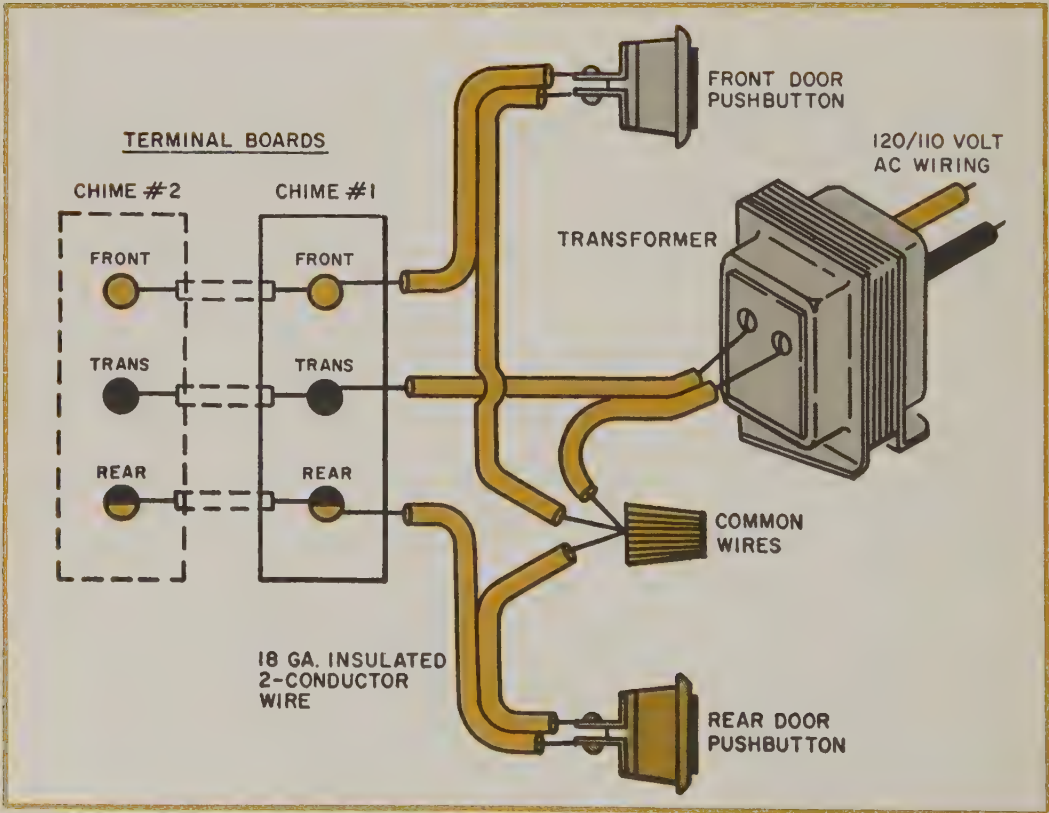


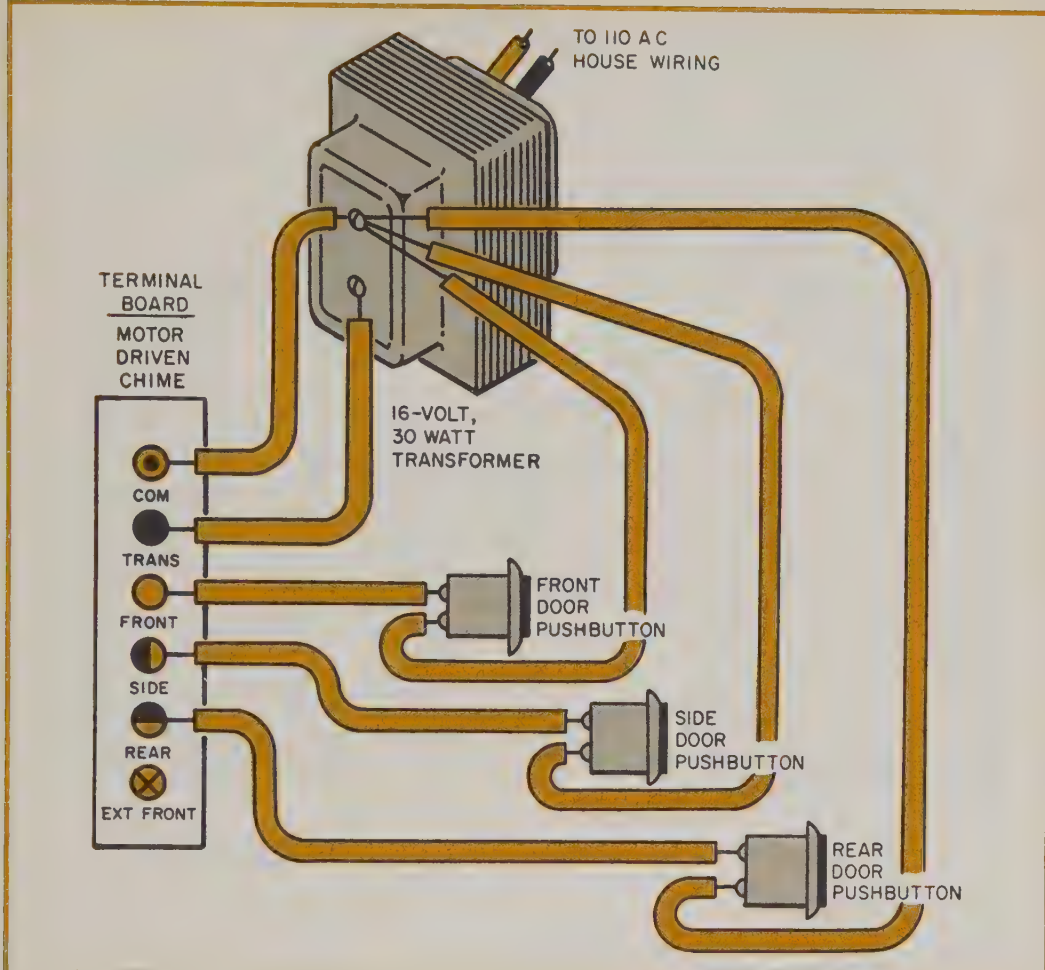
KEY TO TERMINAL BOARD SYMBOLS

	TRANSFORMER COMMON
	TRANSFORMER
	FRONT DOOR
	SIDE DOOR
	REAR DOOR
	EXTENSION FRONT

ate only a single, small chime. A two-note chime requires a 16-volt, 10-watt transformer and a multiple chime installation should have a 16-volt, 15-watt transformer.

▼ In a typical installation six wires lead into ordinary two-note chime. Three of these wires connect to the terminal block, while the others are joined with a wire nut. In some of the chime systems, solenoids are used to strike tone bars, instead of the usual hanging tubes, in order to produce sounds.

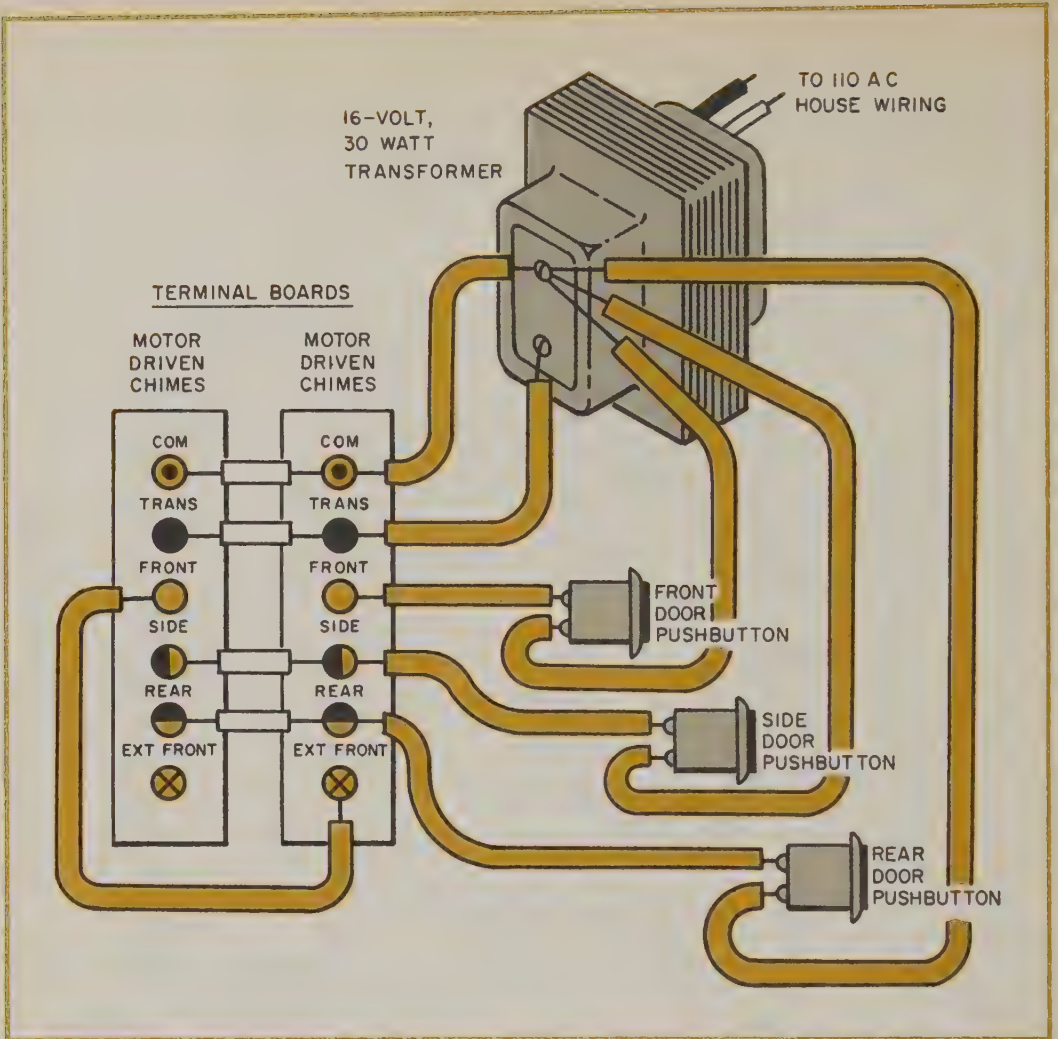




The transformer may be located wherever it can most conveniently tap the main power lines of the house, while keeping the low-voltage wiring as short and simple as possible. In new homes, the transformer is usually mounted on the side of the main circuit breaker box on the panel board. To mount in this location, drill bolt holes in the side of the box, and also a larger hole to feed the black and white transformer wires into the box. Use a ceramic bushing in the hole to protect the wire insulation. Connect the wires to any 15-ampere, 110-volt circuit within the box, taking care to connect the black wire to the existing black circuit and the white to white.

▲ Circuit diagram for one motor driven chime system. Some chimes feature an adjustable volume control (not shown). More elegant systems sound different tones for different doors.

Alternatively, you can mount the transformer onto any handy junction box. Mount only on metal, and do not allow the transformer to touch combustible materials, including wood. Also, keep the transformer out of the attic where it may overheat during the hot summer months. Be sure to turn off the house power when making connections to the 110-volt lines. The low-voltage terminals of the transformer pose no hazards, hence the house power need



▲ Circuit diagram for two motor driven chimes. Some chimes are concealed in wall clocks or are disguised as decorative foyer lights.

not be turned off when connecting the chime wires.

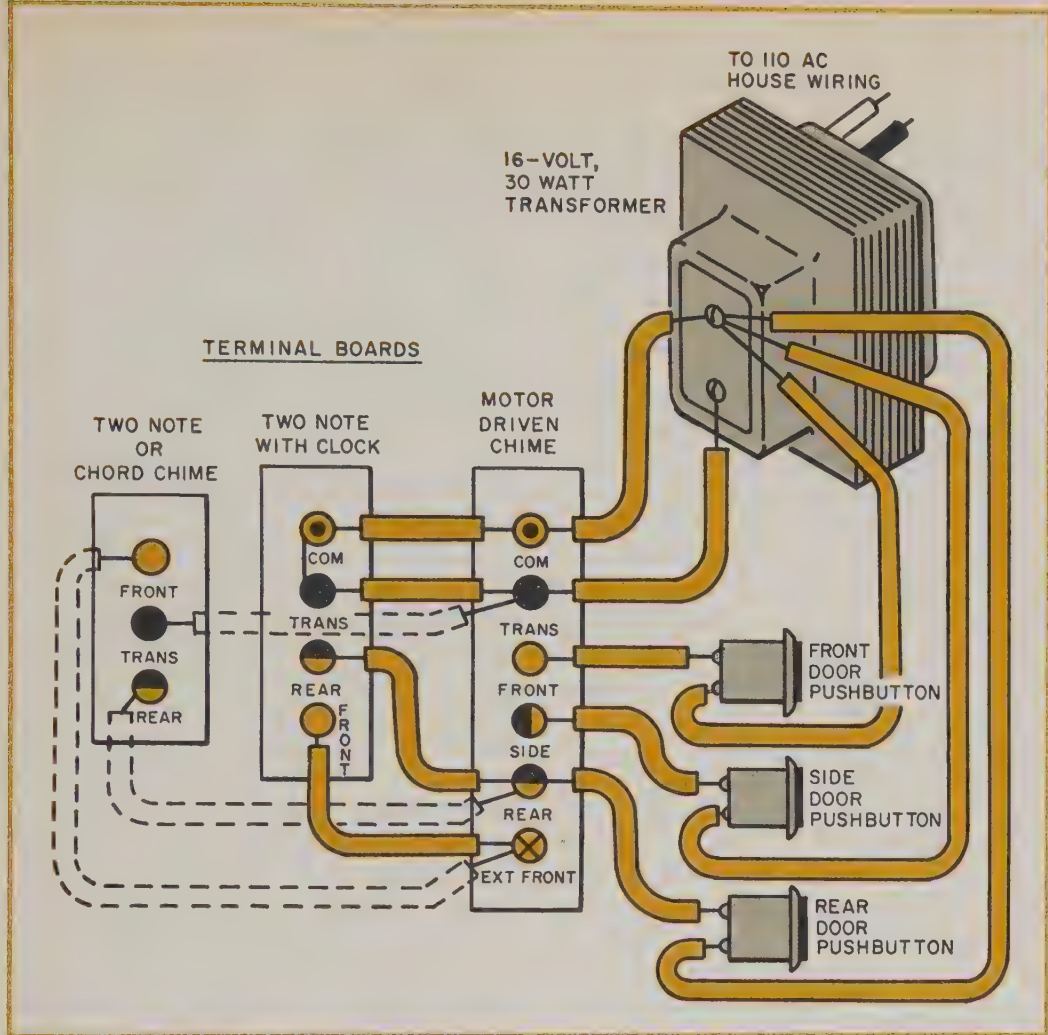
The wiring of a single chime is easy if you use 2-conductor, 18-gauge wire. Just connect the two wire ends to the low-voltage terminals of the transformer and run to the chime; attach one wire to the chime terminal marked "transformer," and leave the other free for the moment.

Use 2-conductor wire to connect each push button to the chime. In each case, one conductor goes to the proper terminal, usually marked "front" or "rear," while the remaining wires—including the free wire

from the transformer—are joined together with a wire nut. This common connection should not be left in the wall, behind the chime box; keep it in the box where it can be reached when testing a malfunctioning chime.

Before placing the cover on the chime box, make sure that the wires do not touch the tone bars, that bared wires touch no part of the chime or box, and that the wires do not interfere with the plungers that strike the tone bars.

No two homes pose the same wiring problems, so it is up to you to map out the shortest and most convenient routes for the wires. If you must snake wires through existing walls, a steel wire snake—available



▲ Circuit diagram for one motor driven chime and one two-note or chord chime. All chimes come with wiring diagrams and instructions. Diagrams shown here are only typical.

from your electrical supply store—will make the job easier.

Often it is easier to drop the wires down into the basement and run them along exposed beams. They may be run from one location to another through the attic. Staples or wire clips can be used to hold the wires to the beams. Be sure that staples are not driven in so hard as to break the wire insulations and cause short circuits. A staple gun speeds the work, however, use a stapler made especially for tacking low-voltage wiring, not one designed for general shop purposes since the sharp-edged, straight-backed staples will surely damage wire insulations.

If a single chime cannot be heard

throughout the house, an extension chime can be added to a remote wing of the house or to another floor. To make the job easier, use 3-conductor wire between the two chimes.

When evaluating the possible need of an extension chime, test the main chime under high noise level conditions. For example, blast the TV in the basement recreation room, or turn on the laundry equipment while someone presses the various push buttons. If you hear the chime only faintly, when you are *expecting* it to sound, you

probably won't hear it at all when normally distracted. A second chime in the basement will eliminate the need to ask: "Did you hear the doorbell ring?"

Also available are more elaborate, *motor driven* chimes that sound as many as eight notes in sequence.

For three-door operation, a motorized chime must have five wires leading to the transformer. Four wires are required for two-door operation, only three wires for one-door use.

Study the diagrams carefully to determine where it is possible to use 2-conductor and 3-conductor wires to simplify the installation. For example, the wires leading from the transformer to the chime terminal board can be of 2-conductor type. Multiple-conductor wires also simplify the job when wiring in a second or third chime.

Otherwise, the diagrams are self-explanatory. Some chimes have a selector switch that permits you to use either a four-note or eight-note signal for the front door. In most chimes the sound volume is pre-set at the factory; however, some models feature a volume control that permits you to adjust the sound level to suit your needs and taste.

If the chosen chime is also an electric clock, the clock power lines are connected across the two transformer terminals on the chime board.

Since modern chimes are highly decorative as well as functional, you will not want to hide your chime. Try to find a good central location where it can be seen as well as heard. Pick the location before selecting a new chime because it may determine what size the chime can be (are long hanging tubes feasible?), and how easily you will be able to mount it.

Built-in chimes, whose faceplates are almost flush with the wall surface, are most easily set into plaster, drywall, or panelled walls. They can be installed into brick walls, but obviously not so easily. If chiseling out mortar and bricks is not to your

Change the Sound of Your Front Door

liking, pick a surface mounted chime that can be hung with a couple of screws. Use a star drill to manually drill the required screw holes; or preferably use a power drill fitted with a masonry drill. A lead anchor sleeve should be hammered into each hole to take the mounting screws.

If the chime fails to operate properly after installation, re-check the wiring to make certain that all wires have been connected to the proper terminals, and that all electrical connections are tight. Also make sure that bare wire touching some part of the chime is not shorting the electrical circuit.

If after such preliminary examination, the chime still fails to operate, examine the solenoid plunger action while someone else pushes the door buttons. The plungers should be able to move freely in their sleeves. If they only quiver or jiggle, see if debris in the tubes has jammed them. If they move only feebly, consider the possibility that you may be using a transformer having voltage output that is too low.

If the plungers show no sign of life, test the transformer by shorting the low-voltage terminals with a screwdriver or a length of wire; a small spark will indicate that the transformer is operating. If you get no spark, you probably have a defective transformer—provided that you remembered to turn the house current back on after tapping the transformer to the main line. If you suspect a dead transformer, use a couple of 9-volt lantern batteries to verify your suspicions if they happen to be available. Just wire the batteries into the chime circuit, in place of the transformer. Hook the batteries in series to get 18 volts. If the chimes work, you have final proof that the transformer is defective.

Properly installed chimes should work for years without trouble. But they are not infallible. If the chimes go dead, make the same checks described above. Also test the push buttons; since they are exposed to out-

Change the Sound of Your Front Door

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door environments, the contact terminals may have become corroded. Suspect the push button if another push button operating the same chime still works.

Some types of push buttons can be opened, and the contacts can be cleaned with fine sandpaper. Newer types have sealed-in contacts that cannot be readily exposed. In this case, just short the exposed terminals, where the wires are attached. If the chime sounds, the push button is obviously defective and should be replaced. If you have trouble getting the push button out of the house wall, test it from the chime end. Disconnect the two wires in the chime box (those leading to the suspected button), and connect them to a flashlight battery and a flashlight bulb—in series. If the bulb lights when the button is pressed, the push button is good.

Sometimes chime plungers become sluggish because of the accumulation of dust and grease. If necessary, clean the plungers with lighter fluid or naphtha, taking care not to drip the solvent onto plastic parts of the chime. *Never* oil the plungers!

It is usually very easy to replace doorbell with a chime. If you have 2-conductor wiring, simply remove the old bell, mount the chime, and attach one wire to the transformer terminal and the other to the “front” terminal inside the chime. If you want the chime to respond to a second door, you may have to add additional wiring.

Perhaps you already have a 3-conductor bell system, but you want to install a new chime. If the existing wires are easily identified, just connect them to the proper terminals. If you are unsure about the wire connections, follow this procedure: Hold down the front door push button and simultaneously hold one wire against the “front” terminal and touch the remaining two wires—one at a time—to the “transformer” terminal inside the chime until you find the combination that produces two notes. After connecting these, attach the third wire to

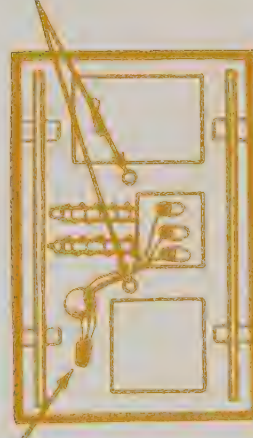
the “rear” terminal and test the rear door push button. If the chime fails to sound, switch the “front” and “transformer” wires.

You can add a chime without bothering with any wiring whatever. The non-electric units mount right onto the door. Some models include a nameplate, others have an optical lens viewer that gives you a wide-angle view of the caller.

The non-electric chimes are fine, even for front doors, in small homes where the chime does not have to be placed at some distance from the door to be heard.

See also: ELECTRICITY; WIRING, ELECTRICAL.

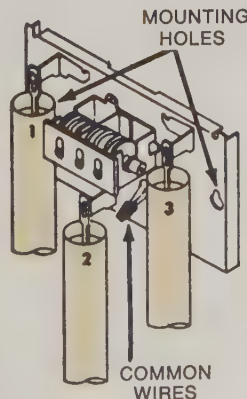
MOUNTING HOLES



COMMON WIRES

FRONT VIEW OF BASEPLATE

▲ Wiring of two-note chime for two doors.



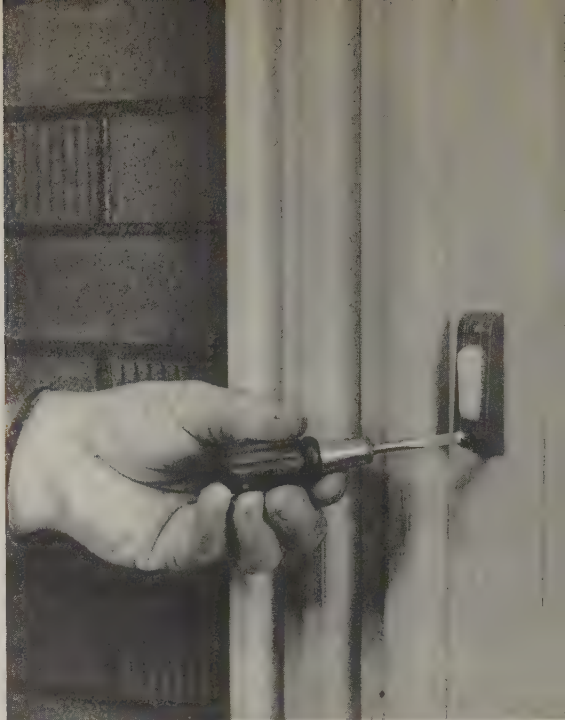
◀ In a chime with three hanging tubes, three wires connect to terminal board, others are joined with wire nut. Keep common wires inside box for easy access.

Easy Installation of Doorbells

Changing or repairing your present doorbell system is an easy job with a little basic knowledge and the aid of wiring diagrams

EVERY HOUSE requires some form of signal from the outside doors to an inside room, so that the presence of visitors can be made known. While the electric bell is used today to a large extent, chimes are also very popular. Stepdown transformers are taking the place of dry and wet cells for powering doorbell systems. These inexpensive units reduce the 115 volts AC to 8 or 10 volts for an ordinary bell and 12 to 16 volts for chimes. For the former, a transformer rated at 5 to 10 watts is generally sufficient, while good chime operation may require a 10 to 20 watt transformer. Lasting indefinitely, these small signal transformers are very good for the job and require no maintenance.

When installing a bell transformer, never secure it to a wooden or other inflammable surface, as it may become quite hot due to a short-circuit in the bell wiring, poor workmanship or design on the part of the manufacturer or other causes. Place it in or on a steel box or cabinet and protect it with 3-ampere fuses. When the box is attached to the existing fuse cabinet, the frame is effectively grounded and no danger of shock exists as when box is secured to an insulating surface.



▲ *The most common source of trouble in doorbells is the push button. Check it first by removing the cover and shorting the screw terminals with a screwdriver.*

Units are available which consist of a bell transformer, fuse block and 3-ampere fuses, mounted in a small metal box. Attach this box to the house fuse cabinet with a short conduit nipple, locknuts and bushings. Run #10 rubber-covered wires from the terminals of the fuse box, through the pipe nipple to the sub-mains in the house cabinet. In some cases there may be enough room inside the fuse cabinet for a transformer, in which case a transformer only is required. This should be considered when laying out a new wiring installation.

When making connections to the house sub-mains, be sure to solder the joints, after cleaning the wires well. It is often possible to extend the new wires from the sub-mains to the transformer cutout by splicing in the grooves of the main cutout blocks with soldered joints. If the sub-mains are quite short in their run to a safety switch or other unit, remove them and install new lengths which can run to the new transformer fuse block without splicing.

Easy Installation of Doorbells

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If the chimes are to be installed, it might be difficult to obtain a built-in transformer with a cutout and box which has a high enough voltage and watt rating to do the job. These are usually designed for operating bells. In such a case, obtain a chime transformer of the proper rating and install it with a cutout block in a small metal cabinet. Make the connections as in the other job.

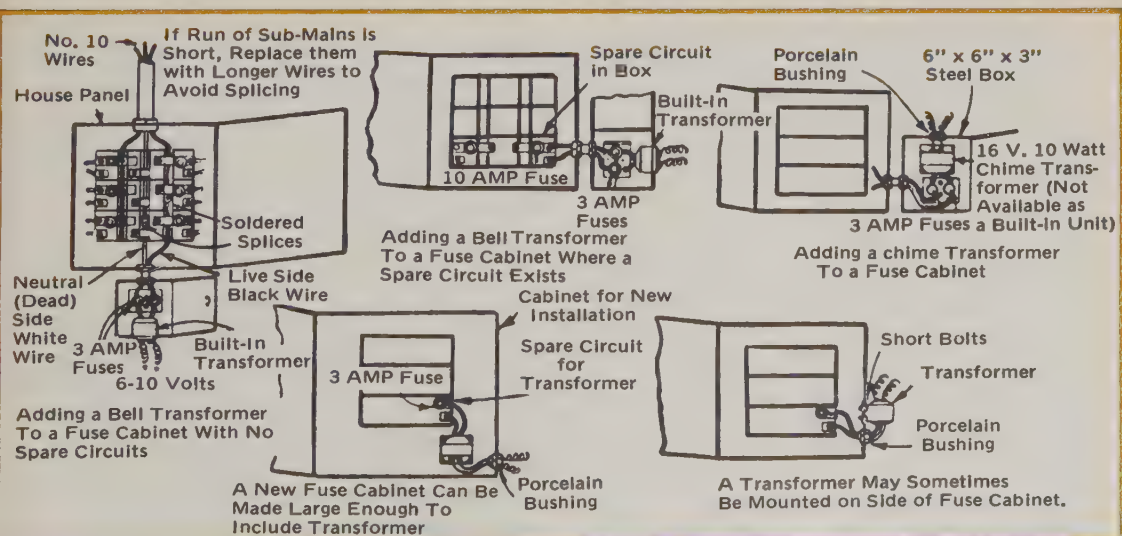
If a spare circuit exists in the house fuse panel, mount transformer in this box, or attach it to the outside with short bolts, carrying the primary wires into the box through a porcelain bushing.

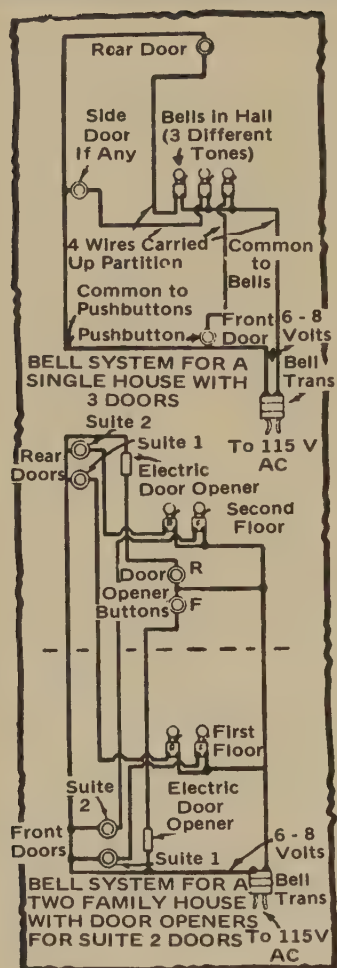
Wiring door bells and chimes is not difficult but the work should be carefully done and rubber covered #18 wire should be used. Do not use cotton insulated wire (annunciator wire or bell wire) since short-circuits can easily develop with this weak insulation.

Bell wiring in new houses is usually installed after the lighting circuits are in place and all partitions are up, but before lathing and plastering has been done. Electric door openers for the front and rear upper doors in a two-family house are installed in the door casings when the house is finished.

They allow you to open the doors from upstairs by pushing a button. A common wire runs from one side of the transformer to one side of all outside units, while another common wire runs from the other side of the transformer to one side of all inside units. Connecting wires between them complete the circuit in each case. Solder and tape any necessary taps or splices in the wires. Many such taps can be eliminated by pulling a loop of the wire out and connecting it around a terminal of the bell or button. Avoid the use of metal staples or nails for supporting the wires, as they may cut into the insulation later and cause trouble. A few insulated staples may be used, if necessary, or a piece of wood can often be made to support the wires.

For carrying the wires up to a push button, in most house construction, use the small space between the door casing and first stud. A hole can be drilled through the outside finish board opposite this space, where button will be attached. Next drill a hole through studs as shown and another on a slant from the basement, through the sill. If the wiring layout is such that it is better to carry the wires up instead of down, bore plate at top of studs rather





▲ Two schematic drawings of double-bell systems, one for a single house and the other for a two-family home with electric door openers for the front and rear upper doors.

than sill, and direct wires towards ceiling to meet a line to bell location.

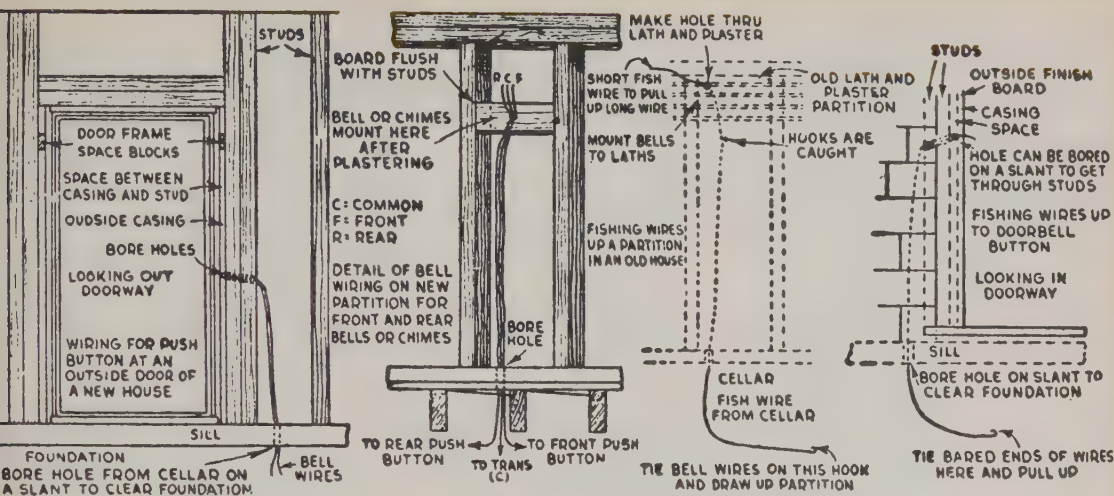
At the bell location in new work, set a board in between the studs to form a support for screws used in securing bells or chimes. This is necessary because the use of rock lath today usually replaces the older wooden laths and screws will not find a hold in it.

Bell wiring in old houses is usually done with the aid of "fish wires" or "snakes," narrow steel tapes that are used to pull wires up partitions and under floors. Heat the ends of the fish wires and form open hooks. Pass one wire through a hole bored as required and work up to the location of the bell or button, where another hole is provided. Use a second wire to catch the hook of the first one so it can be brought out the hole. Wrap bared ends tightly around hooked lower end of fish wire and draw them in.

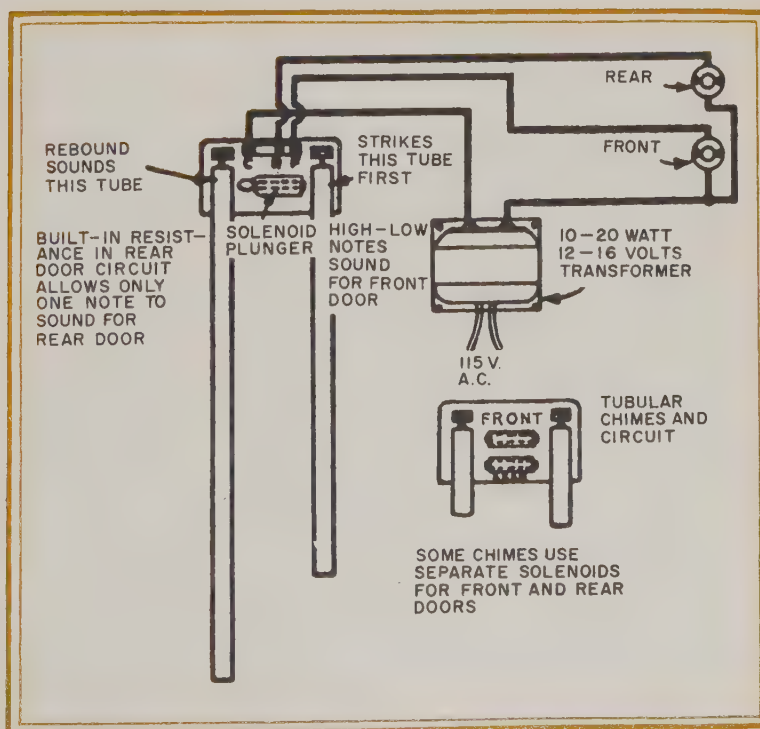
The installation of chimes is not much different from that of bells. For a set of two-door tubular chimes, three wires are required, as with a pair of bells for two doors. One is a common wire and the other two run to the doors. Use wires with different colored insulation for quick identification. In some types of chimes a felt or rubber mounted bar is struck, instead of the long tubes, which is common construction with the lower priced chimes. These may also have short tubes for decorative effect or increased tone quality, although they are not actually struck. A solenoid is usually used with a plunger as the striking force.

In the long tubular chimes one type uses a single solenoid for both door signals. When the push button closes the circuit at the front door, the plunger strikes the shorter tube, producing the high note. Upon release of the button, a spring on the solenoid returns the plunger with enough force to strike the long tube for the low note. For the rear door signal, a built-in adjustable resistance prevents the plunger from striking the short tube, but the spring returns it from its restricted forward motion to strike the long tube. In the two-solenoid type separate units are used for each door, usually resulting in an improved sounding of the chimes. Chimes are also available that sound all eight notes of the Westminster chimes, at each press of the door

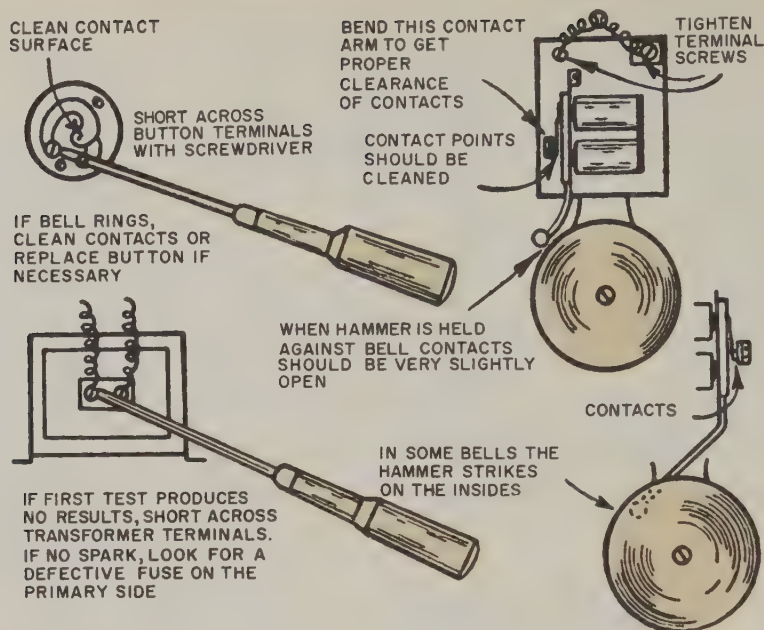
Easy Installation of Doorbells



▲ Diagram shows method of carrying wires from doorbell inside the home to a push button mounted on an outside wall. Method of securing bell wires inside the wall is also shown.



➤ In push button operated chimes, the button closes the circuit at the front door causing the plunger to strike the short tube that produces a high note; when button is released, a spring on the solenoid returns the plunger to strike the long tube, producing the low note.



button. Full wiring instructions are usually included with the purchase of these more complicated musical units.

By far the most common source of trouble in doorbells is the push button, because of its location outside the house. Contacts corrode in time, making high resistance points. Check the button first, remove the cover and try shorting across the screw terminals with a screwdriver. If the bell rings, cleaning the contacts is necessary. Draw a strip of folded fine sandpaper between them, holding the top spring piece down for pressure. If inspection reveals extreme corrosion at the points of contacts, purchase a new button. If the bell still refuses to ring, check the transformer for output by touching a screwdriver blade across its secondary. A spark should be seen in this test, otherwise inspect the fuses. If they are working properly, the transformer winding may be open circuited.

If further search is required, have someone hold the button in contact while you remove the bell cover to see if movement of the flat armature with the fingers results

in starting it to ring. The contacts may need adjusting or are not clean. To adjust a bell, hold the hammer against the gong. In this position, the contacts should be open slightly. Bending the fixed contact piece or adjusting a screw if one exists will allow proper adjustment to be made. Next, draw a piece of fine folded sandpaper between the contacts to clean them. Also, check for loose or broken wires at the terminal posts. The substitution of a bell known to be operative will determine if the trouble is in the bell.

With some of the lower priced bells, the wires from the magnets are wrapped around a projecting tab on the fixed contact terminal, and a wrapped joint is made at one of the main terminal posts. This is often the source of trouble, and a drop of solder on these two places will eliminate a poor connection.

Be sure to solder all joints. In time, unsoldered joints develop high resistance to the flow of current, and may prevent the bell from ringing.

H.P.S.

See also: ELECTRICITY; WIRING, ELECTRICAL.

How to Free Sticking Doors

Use these tips to make
your doors and latches operate
faultlessly

HOUSE DOORS stick or bind either because damp weather has made them swell, or because the building has settled unevenly, throwing the door frame out of square. The simplest and obvious remedy is, of course, to plane down the edge of the door that rubs to provide clearance between door and door frame. This method is all right for the top or bottom edge of the door, however, since the paint or other finish on the lock-edge of the door is also removed while planing, you may wind up with a paint touch-up job requiring more work than if other methods were used.

So, before you plane the lock-edge of the door, look along the hinged edge of the door when it is closed to see if there is a gap between the door and frame. By reducing or closing this gap by shimming the hinges you may provide enough space at the top, bottom or lock-edge of the door to eliminate binding.

If door sticks along top edge or at bottom of lock-edge, first loosen screws in lower hinge leaf attached to door frame or jamb and shift door to lift back edge of

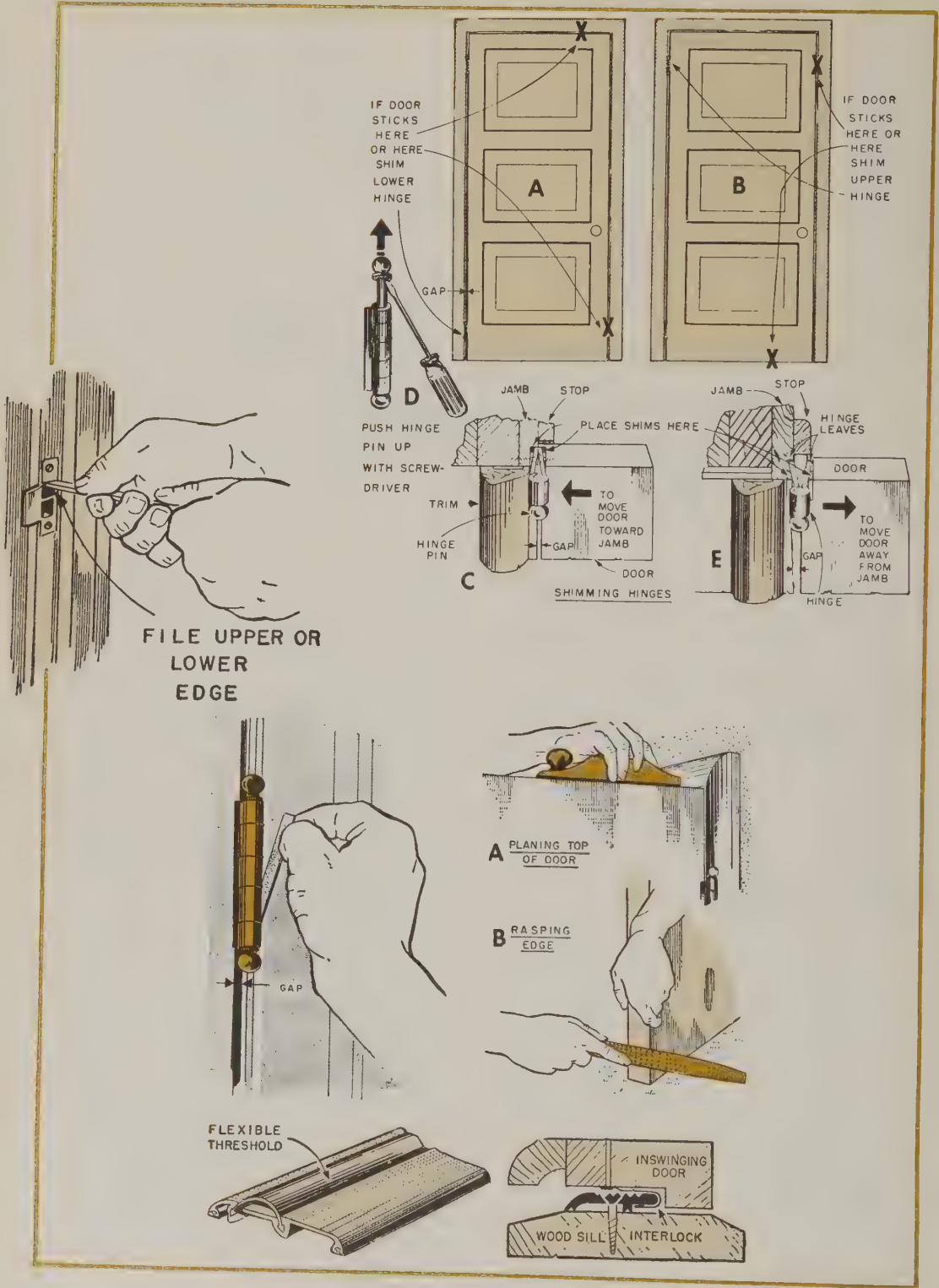
leaf out of its mortise. Take care not to splinter the jamb at the end of the mortise. Then slip a ¼-inch wide strip of cardboard behind hinge, between screws and stop-edge of mortise, and retighten screws. If the door still rubs, also shim hinge leaf fastened to door.

If shimming raises a hinge leaf so it is not flush with door jamb or door edge, remove hinge pin, unscrew the leaves, and swing the door aside enough to chisel out a thin shaving from the bottom of the mortise. Then screw the hinge back in place. Such shimming, or deepening of the mortise, naturally is limited to closing the gap, if one exists, between door and jamb on the hinge edge when the door is closed.

If door sticks along the threshold or top of lock-edge, shim the upper hinge following the same procedure described above.

In rare instances the door may be "hinge bound" (hinge leaves coming together before the door is completely closed). This racks the door and tends to crack the paint at the joints. Reverse the shimming procedure and slip the cardboard shim behind

doors, cabinet: see drawers
doors, garage: see garage door, overhead
doors, painting: see painting, house
doors, storm: see storm doors and windows



How to Free Sticking Doors

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▲ *Installing a door latch keeper. After the keeper is bedded in its mortise, use a chisel to excavate recesses for latch and bolt.*

➤ *Replacing a cracked and unsightly door panel is a time-consuming task. It's easier to install a new panel, as shown here, right over the old one.*



the hinge, provided the space between the door and the jamb at the hinge edge is sufficient to allow reducing it without causing the edge to rub the jamb.

Drawing in the upper hinge moves the top of the door at the lock-edge away from the jamb and raises it off the threshold because the door swivels a wee bit on the lower hinge. This effect is increased by shimming the lower by placing the shims at the front of the hinge. Although movement of the door by shimming the hinges is slight, it is sometimes enough to relieve binding without further treatment.

If the door still binds after the hinge-shim treatment, plane the offending edge or end, removing no more wood than is necessary and beveling it about $\frac{1}{16}$ -inch toward the stop side to give closing clearance. Sand smooth and break the corners. In close quarters, as when dressing the top near the hinge edge or the lock stile at the bottom, a double-end block plane with the cutter set in the nose position is handy. Lacking this tool, use a wood rasp followed by a wood file and sandpaper. Postpone touch-

ing up with paint until the door is dry; then seal edges and ends and bare spots on the faces of the door.

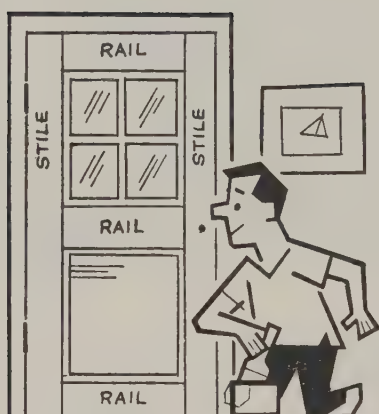
If an outside door sticks or rubs at the bottom against the threshold it is probably due to moisture swelling the lower part of the door. Since this condition is likely to repeat, the best treatment is to lift the hinge pins, remove the door and cut off the bottom enough to apply weatherstripping, preferably the type having a metal threshold and interlocking member or flexible threshold.

Door latching troubles. Refusal of the lock bolt or knob latch to enter the keeper plate on the frame jamb is usually due to settling of the building. Hinge-shimming to lift or lower the lock-edge of the door may help. If not, file the lower or upper edge of the keeper to clear the bolt. If too much filing is needed, raise or lower the keeper by extending its mortise, plugging the old screw holes with a matchstick dipped in glue. Putty the surplus mortise and then finish by touching up with paint. E.M.L.

See also: WEATHER-STRIPPING; LOCKS.

How to Paint a Door

Use these tips to get the job done the easy way



▲ Strip all removable hardware from door except hinges and latch mechanism. If door has windows or recessed panels first paint the muntins (wood strips that separate windows), then the trim around the windows and panels.



▲ Now paint the surfaces of the panels, finishing them with lightly feathered vertical strokes. Next, the rails are painted using long horizontal strokes that just pass the edge of the stiles. Work from top to bottom.



▲ Paint the stiles next. Brush down from the top in long straight sweeps, and finish with a series of upward vertical strokes from the bottom that feather off to nothing as they lap the bottom edge of the downward strokes.



▲ Finally the door's side edges are painted. If the adjoining rooms are different colors, paint the door's latch edge the same color as the room into which it opens; paint the hinge edge the color of the adjoining room.



Build a Dormer on a Weekend

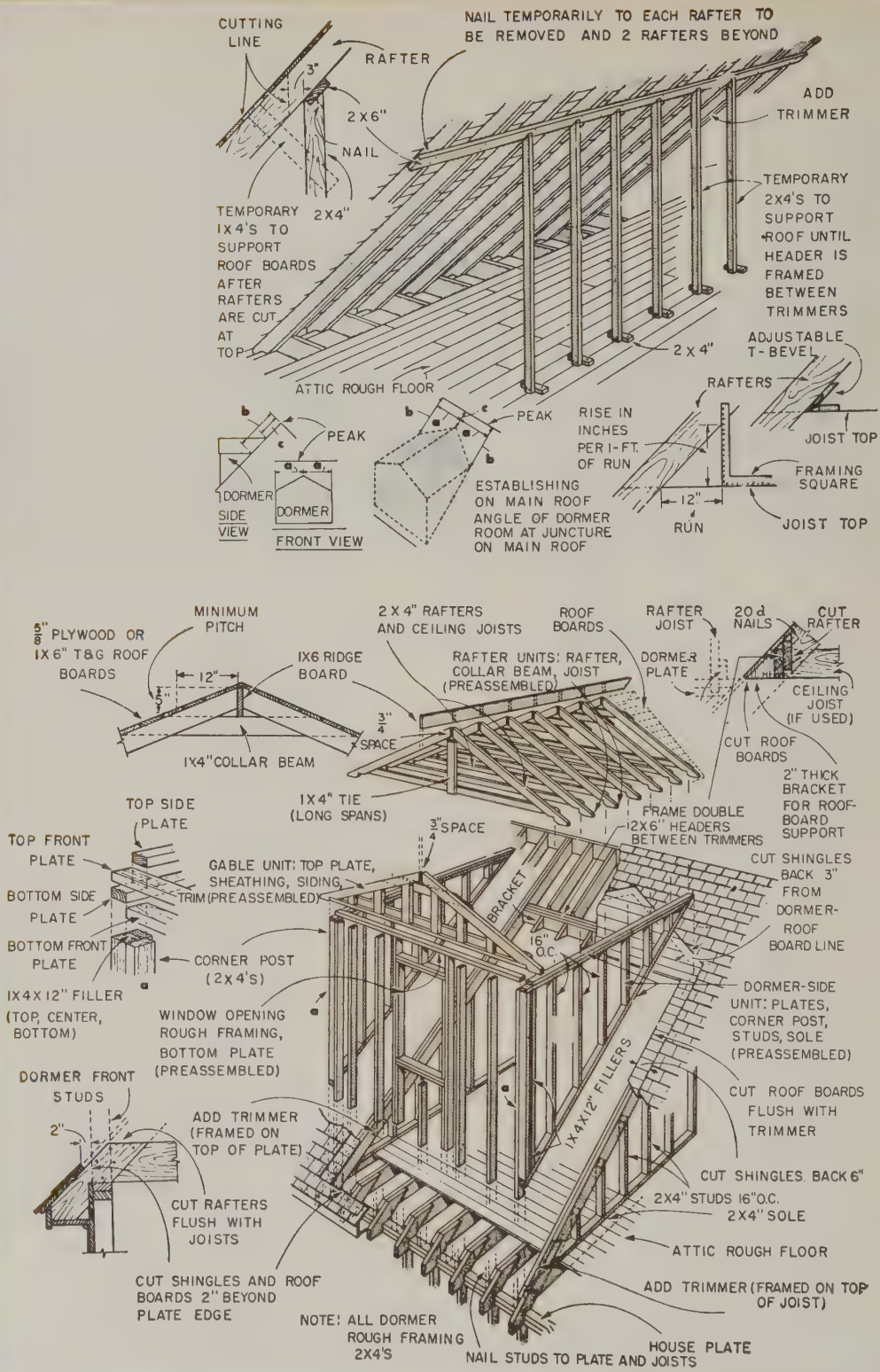
The whole job takes two days, but, by measuring, cutting and assembling in advance, you and a friend can open the roof and get enough of the dormer installed in one day to keep out the weather

DOES YOUR HOME have sufficient roof-peak height in the attic to allow for a dormer? You can, with the help of a friend, install a dormer and make it weather-tight enough in one day to protect your home! From cutting the opening in your present roof to completing the dormer should not take more than two days. The trick is in constructing and partially preassembling the various components of the dormer on the ground so that after the opening in the roof has been cut the preassemblies will fit into place without wasting time for on-the-job cutting and fitting.

Of the three types of dormer roofs, the gable, hip and shed, the gable is the most practical for the preassembly method because of its truss-type construction. Your first decision is the location of your proposed dormer. If your home already has dormers and you need a third, locate it on the opposite roof side between the existing ones to lessen the strain on the roof. If the dormer is for the purpose of an extra bathroom, location of existing plumbing (vent stack) automatically determines its location. Try to center the window or windows.

After deciding on location, your next step is to make accurate scale drawings of the dormer construction based on existing rough framing, that is, accurately measured locations of existing rafters, joists, and the like. This is important since your dormer construction will rest on and be attached to these existing structural members. The larger the scale the more accurately you'll be able to dimension your drawings. A $\frac{1}{8}$ -inch equals 1 inch scale is ideal for accuracy which, in architect's language, is $1\frac{1}{2}$

double-pane windows: see windows
double-duty closets: see closets
dove hunting: see hunting
dovetailing jig: see router
dovetail joints: see woodworking



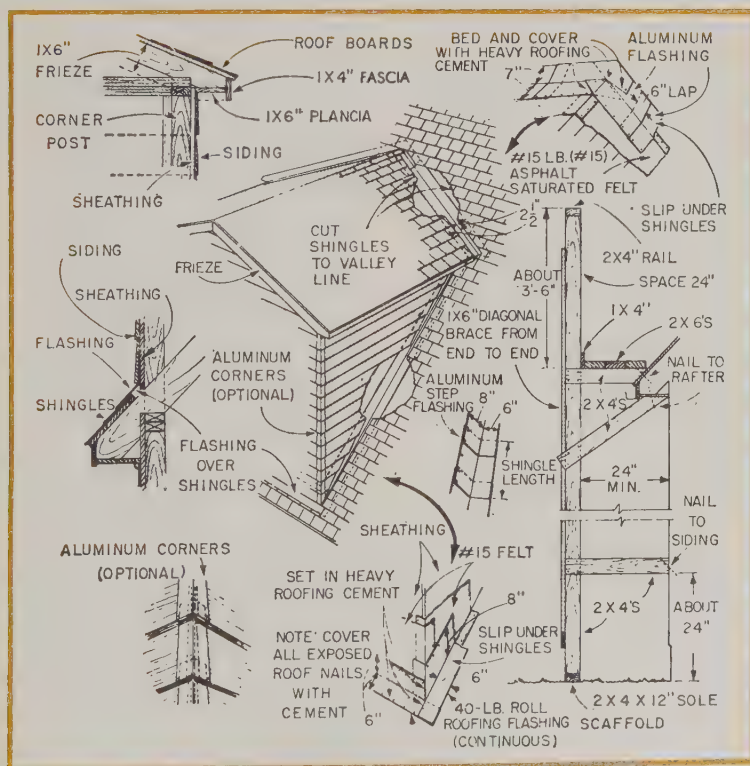
Build a Dormer on a Weekend

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inches equals 1 foot. A triangular-shaped scale having the above and many other ratios is obtainable at any art-supply store. To obtain the pitch or angle of your present roof, use an adjustable T-bevel. All angles of dormer side framing and the like can then be scribed with the T-bevel setting for accurate cutting and fitting. For drawing purposes, you can use a carpenter's framing square to determine the rise in inches per foot of run, which can then be transferred to your drawings as such, or the degree of angle then taken with a protractor. Getting the correct angle of your existing roof is vital for dormer construction, so double-check the findings of the framing-square method against the T-bevel method—the degree of angle must be identical. To have your preassemblies fit into place within the opening area in your roof, you'll need at least a detailed front view of all dormer structural members and existing structural

house members. (Studs rests on house plate, nailed to it, and against joists or rafters wherever possible.) You'll also need a detailed side view of roof and side-wall structural members as indicated in the perspective views and sections. Dimension your drawings plentifully (length of every piece noted) so that you need refer only to them rather than to the house itself when cutting and fitting your preassemblies on the ground. The degree of pitch to your dormer roof is to a great extent governed by the existing roof height; the least amount of pitch allowable for a shingled roof being a 5-inch rise per 1-foot run—or $22\frac{1}{2}^\circ$.

Your working drawings having been completed, checked and double-checked, you can order your lumber. Lumber requirements must be calculated from your scale drawings in the actual sizes in which it is furnished. For all lumber dressed on two or more sides these actual sizes are



slightly less than the nominal sizes used when ordering. Lumber costs are based on the board foot, which is a nominal 1 x 12 x 12 inches.

Your lumber delivered, you can begin cutting, fitting and partially assembling the various dormer components. If your dormer front is going to be nearly 10 feet wide, preassemble permanently only that portion for the rough window framing and bottom plate. Otherwise, the assembly will be too heavy to hoist into place. To keep this assembly square, nail a temporary 1 x 6-inch brace diagonally across on the inside. Balance of front studs are cut to size on the ground and framed after preassembly is in place. The dormer sides rough framing, being relatively lighter in weight, can be permanently assembled. Note the corner-post construction with its interlocking top and bottom plates which enables you to frame the front easily and quickly. The three-member post allows for nailing surfaces for interior wall material. Studs, whenever possible, should be 16 inches apart between centers for easy application of interior wall materials which come in panels 4 feet wide, designed for this spacing. The gable-end framing can be completely preassembled, being a relatively small unit: rough framing, sheathing, 15-pound (#15) asphalt-impregnated felt, siding and frieze. If you plan to use a gable ventilator, that too can more easily be fitted in place on the ground. These aluminum ventilators come in various sizes, square and triangular in shape. All that is required to attach them is to frame 2 x 4-inch backing of the correct opening size. They are nailed over the sheathing with the siding material lapping the edges slightly for a weather-tight joint. Normally, dormers do not have ventilators if adequate ventilators have been installed in the main-roof-gable ends.

A word about sheathing materials. You have a choice of three types: 1) tongue-

and-groove (T&G) boards (nominal 1-inch, usually 6-inch, width); 2) asphalt-saturated fiber panels ($\frac{1}{2}$ - and $\frac{25}{32}$ -inch thick); 3) fir plywood, sheathing grade, $\frac{5}{16}$ - to $\frac{3}{4}$ -inch thick ($\frac{1}{2}$ -inch usually used for walls, $\frac{5}{8}$ -inch for roofs). T&G boards, as sheathing material, are being supplanted by insulation and plywood panels, although the former make the tightest joints. They must be laid with tongue towards roof peak. Insulation panels afford better insulation but require special self-clinching nails for siding materials except over studs. Plywood is most commonly used because of speed in applying it, its rigidity and because it will take standard nails at any point. Since it comes in panels from 4 x 8 feet to 4 x 10 feet, large surfaces can be sheathed quickly.

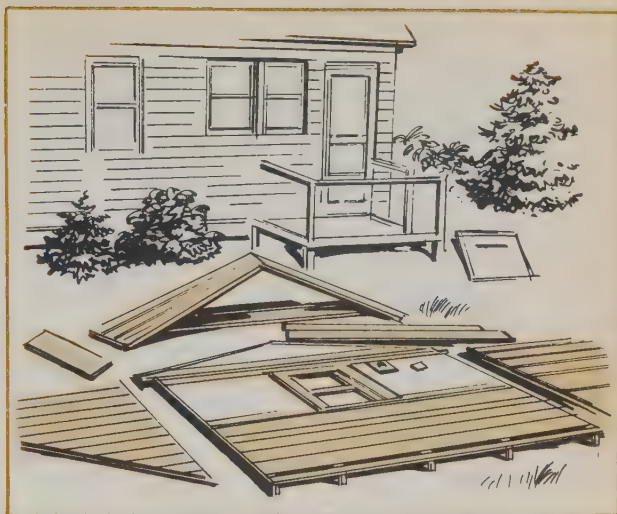
The dormer-roof-structural members can be permanently preassembled: rafters, collar beams and ceiling joists. Allow a $\frac{3}{4}$ -inch space between rafter ends at peak for on-the-job insertion and nailing of a 1 x 6-inch ridge board. You can now temporarily assemble the roof members, correctly spaced, insert ridge board and temporarily tack on sheathing material for correct fitting and cutting. If T&G sheathing boards are used, mark on each the rafter center and drill small lead holes for nails; also code each board with a letter and number so that final assembly can be speeded up. Example: Starting at the bottom, letter "R" for right, "L" for left side and consecutive numbers—1, 2, 3, etc. Identify in some way panel sheathing pieces, if used instead of boards. Sheathing material should be beveled to roof angle where it joins main roof. Also mark and code location of each rafter unit on side plates.

Next, fit sheathing over dormer frames, tacking here and there for accuracy; then, fit and cut siding material, but do not nail permanently. Also code these materials for quick identification on the job, and drill small lead holes for nails into studs and the

Build a Dormer on a Weekend

➤ Sheathing and siding material is fitted, cut and coded on front and side framing for quick assembly once frames are permanently in place.

▼ Preassembled rough framing permanently in place and nailed. Dormer-gable end was permanently assembled on the ground.



like. The dormer siding material should be the same as the rest of your house, its application determined by the type. In our case, we used beveled, ship-lap siding which made assembly easy and fast. If your house has regular beveled siding, the ship-lap type will approximate its appearance and it is available in various widths.

Preassembled windows are sold by all lumber yards, complete with drip cap, sill and trim, needing only to be inserted and nailed into the rough-frame-opening. Before designing and building your rough-frame-opening (which should be slightly larger than window), ask your lumber dealer for the rough-opening size required for the particular window you have in mind. When installing, use shingles as wedges between window casing and rough frame to align window, then nail to studs with wedges in place; saw off surplus wedges flush. Before installing window, give it a coat of exterior primer, inside and out.

A carefully constructed scaffold not only

is a must for maximum safety, but also expedites cutting the roof opening and final installation. Double-headed scaffolding nails can be used for easier dismantling. Sturdy ladders alongside the proposed roof opening are also a must. They must be securely anchored to avoid accidents.

Before any roof cutting can be done, the roof must be reinforced; first, temporarily, to allow cutting the opening, then permanently by framing and nailing two headers of roof-rafter size to cut rafter ends and trimmer rafters on each side of the opening. Before temporary bracing is installed, however, frame an extra rafter to each rafter on each side of the proposed opening; that is, accurately fit rafter against existing ridge board and, in one instance, to top of floor joist, in the other to house plate. These doubled rafters now become trimmers. Nail them securely together with 10d nails from both sides, spaced 16 inches, staggering location of nails. Also nail securely with 10d nails to ridge board, top of joist and plate. These added rafters must fit snugly against ridge board, joist and plate. Now, temporarily brace roof. To establish cutting lines of roof opening, drive a few nails through roof from inside along side of trimmers, at top and bottom; then, from outside, draw chalk lines on roof and remove nails. To establish dormer roof angle

where it joins main roof, carefully snap or draw chalk lines on roof. From this line you can then establish chalk lines for cutting shingles. If your shingles are of the asphalt type, a linoleum-cutting knife or a special detachable-bladed knife for this purpose will make the job much easier. With all lines established, cut out shingles and saw roof sheathing and remove, leaving exposed rafters. Then, cut rafters at top from inside and temporarily brace remaining roof sheathing. Now, saw off rafters at eave flush with joist tops and remove rafters. Nail rafter extensions securely to joists. Snugly fit headers between trimmers and nail first header to each cut rafter end and securely to trimmers; then, other header to first and to trimmers. Nail brackets to headers and remaining roof sheathing. You are now ready to assemble and nail into place your dormer components, starting with the two sides. Level and plumb components with a carpenter's level and temporarily brace front assembly with a 1 x 6-inch diagonal brace from the inside, allowing it to remain in place until dormer is completely finished.

With all rough-framing components securely nailed into place, attach prefitted

and precut sheathing material, then, #15 felt with staples or roof nails. You must then install flashing at juncture of dormer roof and main roof, called valley flashing, and along the sides where they join main roof. Copper or aluminum valley flashing is best. If copper is used, all joints should be soldered. Flashing must be slipped under existing main roof shingles, requiring lifting nailed shingles which, when flashing is in place, must be renailed. Cover all exposed roof nails with heavy roofing cement, forcing cement well around and over nails with a putty knife. Flashing along sides of dormer can be top-grade roll roofing (not less than 40-lb. type), or aluminum step flashing. With step flashing, each section should be slipped under corresponding shingle line. Here, too, shingles may have to be lifted and renailed, as with the valley flashing. Where dormer front joins roof extension, flashing must be attached over existing shingles, cemented and nailed in place.

With flashing in place, you can now apply shingles to dormer roof (instructions for installation come with the shingles). This done, you can nail into place your precut siding material. To avoid the chore of mitering beveled siding at corners, difficult to fit properly on preassemblies, you can use aluminum siding or shingle corners. These enable you to cut your siding to fit the corners flush, the preformed corners making a weather-tight joint. Finally, attach plancia and fascia boards to dormer eaves and you're ready to prime coat the completed dormer. If aluminum corners are used, apply an aluminum primer to them. When primer coat is thoroughly dry, one or two exterior finish coats complete your dormer.

It took two days from the starting of the cutting of the roof opening to the installing and finishing of the dormer. F.B., A.Y.

See also: ATTIC; HOME IMPROVEMENTS; ADDITIONS, HOME.

LUMBER DATA		
Actual size inches	Nominal size inches	Board feet foot of length
2 ³ / ₃₂ x 1 ⁵ / ₈	1 x 2	1/8
2 ³ / ₃₂ x 3 ⁵ / ₈	1 x 4	1/3
2 ³ / ₃₂ x 5 ⁵ / ₈	1 x 6	1/2
2 ³ / ₃₂ x 9 ¹ / ₂	1 x 10	3/4
2 ³ / ₃₂ x 11 ¹ / ₂	1 x 12	1
1 ⁵ / ₈ x 3 ⁵ / ₈	2 x 4	3/4
1 ⁵ / ₈ x 5 ⁵ / ₈	2 x 6	1
1 ⁵ / ₈ x 9 ¹ / ₂	2 x 10	1 ³ / ₄
1 ⁵ / ₈ x 11 ¹ / ₂	2 x 12	2
2 ⁵ / ₈ x 5 ⁵ / ₈	3 x 6	1 ¹ / ₂
3 ⁵ / ₈ x 3 ⁵ / ₈	4 x 4	1 ¹ / ₄
3 ⁵ / ₈ x 5 ⁵ / ₈	4 x 6	2

Dowels and Their Uses

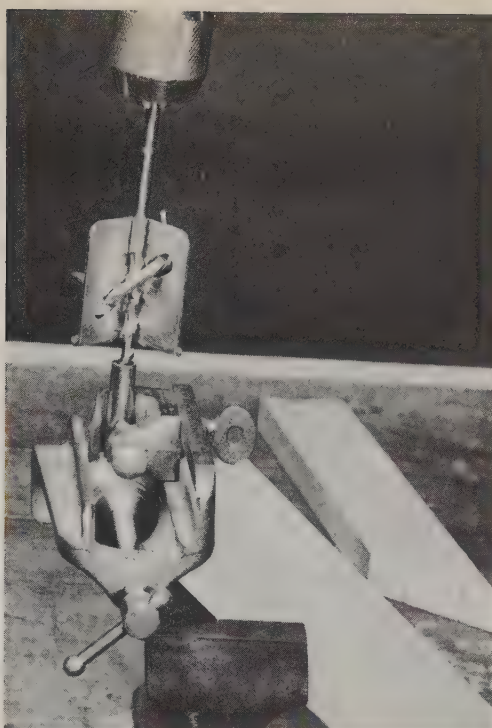
Dowels and glue have several advantages over screws or other means of fastening joints in wood, and they are easy to install, if you use an inexpensive doweling jig

FOR MANY WOODWORKING PROJECTS, doweling is the most practical method of fastening. Dowels make a strong joint, do not split the wood as metal fasteners often do and contribute to the appearance of the cabinet or other furniture by avoiding the necessity for unsightly nails or screws.

Doweling isn't as tricky as it appears. A simple low-cost tool locates the dowel holes accurately and guides the drill for straight boring. After a bit of experience, doweling becomes a routine operation with all guesswork eliminated and good results assured.

Dowels, commonly made of birch or maple wood, are sold in 36-inch lengths and diameters from $\frac{1}{8}$ to 3 inches, including the common 1½-inch clothes pole dowel. The sizes most often used for cabinetwork are $\frac{3}{8}$ - and $\frac{1}{2}$ -inch diameters, available in 2-inch lengths with spiral grooves that prevent "glue lock" in the holes, and tapered ends for easier insertion.

There are two types of dowel joint. One is the *open-end* in which the dowel is driven



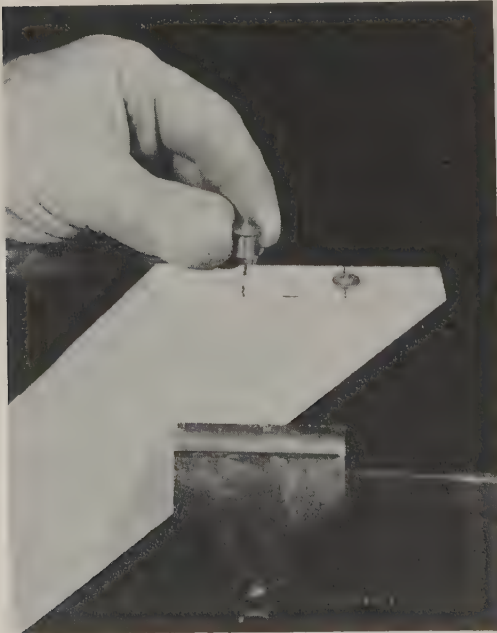
▲ Doweling jig used here to bore holes for a mitered joint has a tubular guide that holds the drill precisely vertical to the stock. Graduated scale permits the jig to be set to the correct position for dowel alignment.

▼ Open-end doweling is easier. Joint parts are held together as dowel holes are drilled through the outside of one part into the other.



➤ *Drilling is done at the exact center. Use a marking gauge to find it. Set the gauge at approximate center and make a mark. Then do the same thing from the other side. Adjust as necessary so that a mark made from either side falls on the same line. That is the center.*

▼ *For blind doweling, the opposing holes must be in perfect alignment. Clamp the parts together and use a try square to draw lines straight across both parts.*



▲ *With the dowel finders in place, press the parts together in perfect alignment. The sharp pins of the dowel finders will mark the centers for the dowel holes on the second part.*

◀ *An alternate method of aligning dowel holes is to use center finders. Drill one set of holes first and put dowel finders in them.*

Dowels and Their Uses

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◀ When holes are correctly aligned and drilled, dowels will be in alignment and the parts will match neatly.

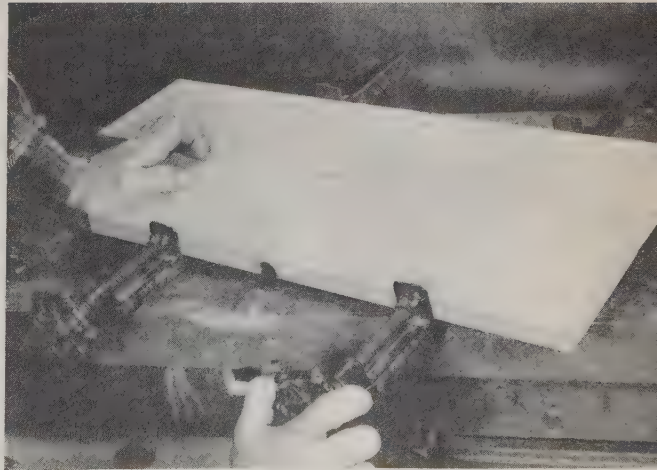
▼ Close-up of dowel jig shows thumb clamps holding stock while the positioning screw locks the jig in place. Note the drill guide collar at the top of the jig.



▼ Blind dowels reinforce edge gluing used to make wider boards. Make sure that dowel holes are drilled at absolute center so the boards will remain flush when joined.



▲ Blind doweling joins parts of square frame. Lines have been drawn across both parts for setting the doweling jig.



through one part and into the second part of the assembly, which is held in place with a clamp. The other is *blind doweling* in which matching holes are drilled part way into each of the parts, the dowels inserted, and the parts forced together so that the dowels remain invisible.

Open-end doweling is the quickest and easiest; it requires no precise measuring. Clamp the parts together in their final position. Drill a hole at the approximate center of the outside width, deeply enough for the dowel to enter at least 1 inch into the joined part. Brush or drip glue into the hole, drive in the dowel as far as it can go, then saw off the excess length flush with the surface. Two or more dowels are needed at each joint.

The drilled hole should be the same diameter as the dowel; when the assembly is joined, the glued dowel becomes an integral part of the wood assembly. The dowel end will be just slightly visible when the cabinet is finished. When it is suitable, use dowels of a contrasting wood. This will result in a pegged appearance.

Blind doweling is used when the dowels are to be concealed. In this method, holes are drilled in perfect alignment with each other so that the dowels will fit when the parts are drawn together. Blind doweling can be done on mitered, curved, tapered or other type of joint.

The best way to accomplish this is with a dowel jig, including drill guides for six common sizes from $\frac{3}{16}$ - to $\frac{1}{2}$ -inch. The jig is clamped onto the edge of the stock and adjusted to the exact center of the wood thickness. When locked at any setting, the jig may be moved from one position to another and retains the original setting, so holes drilled through the guide tubes are uniformly positioned and will line up.

Another method, which is not always as precise, uses short plugs with sharp metal pins at the center. When the plug is placed into a drilled hole and the parts brought

together, the pins indent their points on the opposite member. Drilled holes at the opposite side will thus be in alignment. The difficulty here is bringing the parts together very carefully so the holes will line up.

When using the jig method, first clamp the wood parts together, then with a try square draw lines across both parts at the desired dowel positions. Set the jig so the index notch is on the guide lines, drill holes deeply enough so there is sufficient clearance for the dowels to go in their entire length—it won't do to have an excess in blind doweling.

The guide collar on the jig assures that the holes are drilled straight and true. Do not alter the jig setting when it is moved from one position to another. Also, to make certain of drilling the correct edge or side of each piece to be joined, mark the positions lightly with pencil.

Brush or drip glue into one set of holes, drive in the dowels with a mallet, then set the second part to be joined to start the dowels in their holes and draw the parts together with a mallet or pipe clamps. Wipe off any squeezed-out glue before it sets.

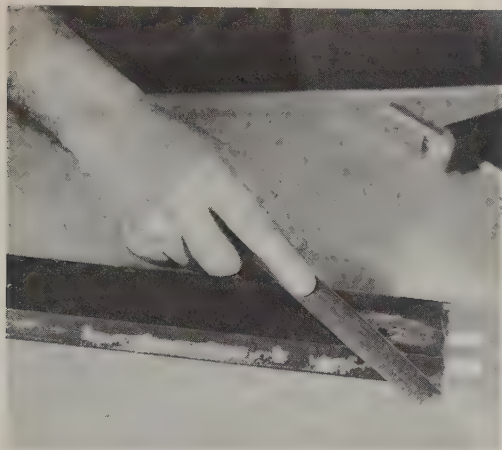
In edge-to-edge doweling, as when two pieces of board are joined to get a greater width, the thing to watch is warped bellying of the wood. If necessary, apply clamps or a heavy weight to keep the edges flush and level when the parts are drawn together to avoid the slight misalignment, and use a sufficient number of dowels for fastening.

When using the pin locating method mentioned earlier, don't rely on the fingers to align the ends of the stock, but rather rest the work on a solid flat surface.

Round tenons of chair stretchers and similar furniture parts are, in effect, dowels. The installation technique for these tenons is more complex than other dowel jointing, but it is quite simple to repair broken and split dowel tenons. Saw off the remainder of the split tenon from the stretcher or

Dowels and Their Uses

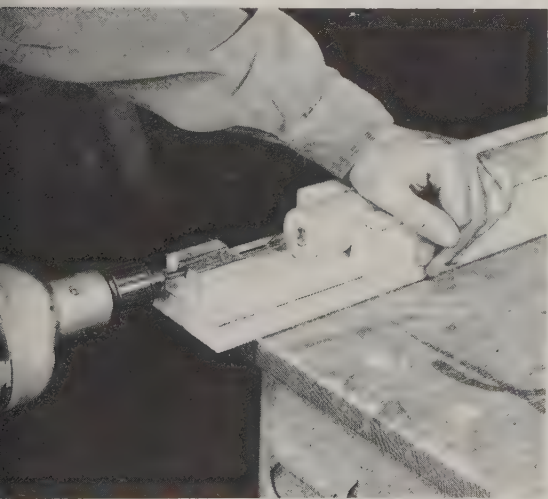
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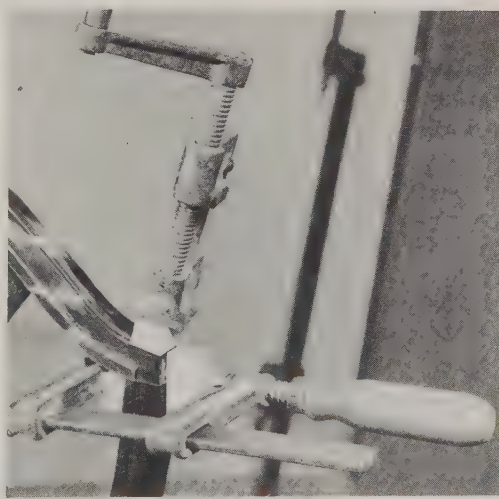
▲ Clean off all old glue from chair rung dowels and replace the dowels in the original holes. Drill holes through center where necessary to clean out the opening.



▲ Reassemble the chair by tapping parts together. Note the squeezed-out glue; this should be removed with a damp rag before it hardens. Clamp the assembled parts while glue sets.



▲ When a split tenon dowel must be drilled out of a tapered chair leg, use a jig like this one to guide the drill.



▲ When irregular parts are joined with dowels, several clamps will be required to apply pressure while holding the parts in alignment.

rail. If there is any remnant in the tenon hole, drill it out, setting the drill point at the exact center of the hole. The way to find the center is to draw lines across the hole opening using the miter gauge on a try square—the center is where the lines cross. Drill a dowel hole at least one inch deep, and the exact diameter of the original

tenon hole, into the sawed tenon of the rail. Glue in the new dowel, then rejoin the rail to the original tenon hole of the furniture leg. If the dowel is too tight, cut a notch along its length to permit release of trapped air and excess glue.

See also: DRILL ATTACHMENTS, POWER; WOODWORKING.

What to Do if the Drain Clogs

With a few special tools and a little know-how you can beat the high costs of plumber's bills and acquire an understanding of the plumbing in your home

WHEN THE WASTE WATER in your sink, lavatory or tub starts to run out slowly it is a sure sign an obstruction is building up somewhere along the drain pipes, and it is likely you will end up with a completely stopped-up waste pipe.

Get at the problem right away, before your line is completely blocked, with a can of chemical drain cleaner or even boiling hot water; it may save you the work and trouble of removing the waste trap pipe under the sink. (If you have a septic tank disposal system be sure to use the type of chemical drain cleaner that will not stop the bacterial action in the septic tank. Check the label on the can.)

Sink and lavatory drains. Grease from washing dishes is the major cause of a clogged kitchen-sink drain. Carried by the warm waste water, the grease solidifies on the bends in the cold drain pipe. Other waste particles become embedded in the hardened grease and before long an obstruction is built up. Chemical drain cleaners generate heat, when mixed with water, which softens the hardened grease so that it will run down the drain. Often a bucket of water heated to the boiling point on the

kitchen range and poured slowly down the sink drain will clean out the solidified grease. Tap water is usually not hot enough to soften the grease.

If the drain is completely blocked so that water is left standing in the sink, do not attempt to ladle out some of the water and pour a chemical cleaner containing lye into the drain pipe. In most cases the cleaner will not reach the obstruction and it may form a hard crystallized deposit in the trap or waste pipe. Such a deposit is extremely difficult to remove and leaves you with a worse stoppage problem than you had in the first place.

Instead, first try to break through the obstruction with a rubber force cup or "plumber's friend." Even though you only get the water to drain slowly, it may be enough so that a chemical cleaner will then flow down to the place of the obstruction, where it can go to work.

When using a force cup on a double-bowl kitchen sink or laundry tub, seal the drain in the sink you're not working in with a sink stopper or a sponge-rubber ball held down firmly over the drain opening. Otherwise the force cup will merely raise the water in the other sink and not remove the obstruction.

The same holds true when using a force cup on the bathroom tub or lavatory drain. Here the overflow openings must be sealed by holding a damp washcloth tightly against the openings to prevent loss of pressure. If the lavatory or tub has a pop-up drain stopper, it should be removed before using

What to Do if the Drain Clogs

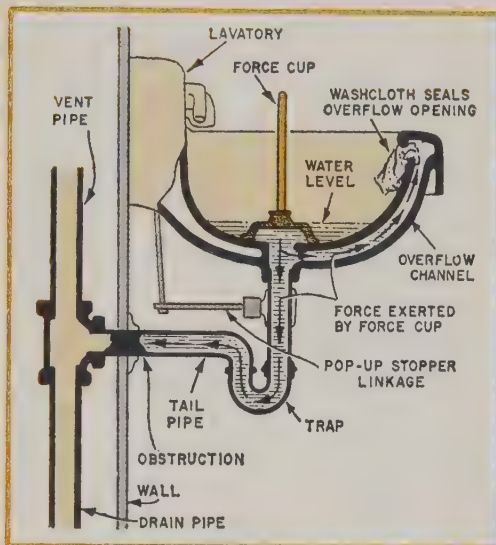
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the force cup. Most pop-up stoppers can be removed quite easily by first setting the stopper control lever or knob in the half open position, and then turning and lifting the stopper. If the stopper is the type that must have the lever disconnected before it can be lifted, remove the lever fitting located under the lavatory on the drain pipe.

Because pop-up type stoppers must have the opening and closing mechanism in the drain pipe, hair and lint collects on the mechanism and retards the flow of waste water. For this reason it's a good idea to remove the pop-up stoppers and clean them every few months.

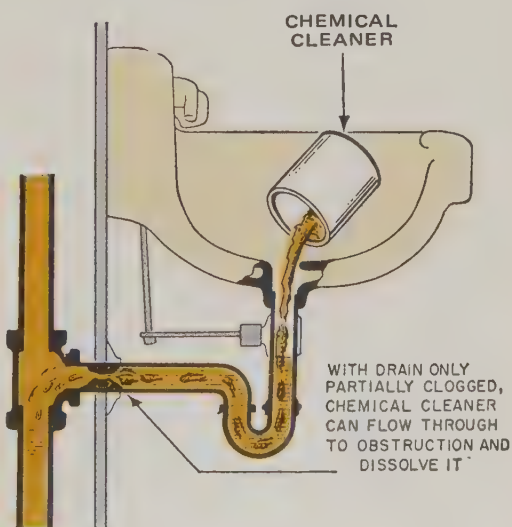
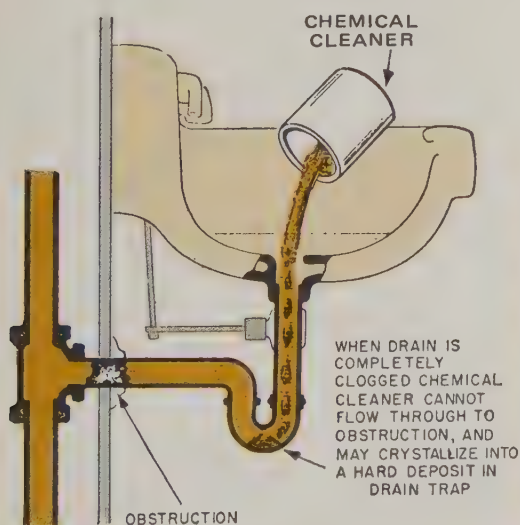
When a clogged drain does not respond to the force cup treatment the only alternative is to remove the trap under the sink and use a soil-pipe snake. Be sure to place a bucket under the trap to catch the waste water in the line before loosening the trap coupling nuts with an adjustable wrench. After the trap is off, inspect the inside and clean it. Very seldom does the trap become clogged to the point where it stops the flow of waste water. Although small heavy objects accidentally dropped in the sink or lavatory drain may become lodged in the trap, the purpose of the trap in the drain

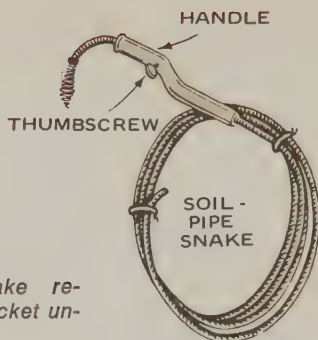
line is to retain water in its V-shape at all times and thus provide an air-lock so that noxious sewer gas can not enter your home.



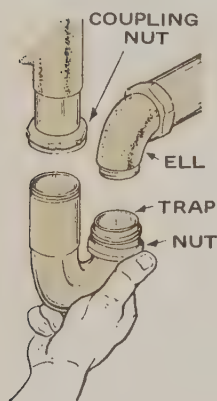
▲ Using a force cup on a lavatory drain. It is important to close the overflow opening with a washcloth to seal in pressure.

▼ Pop-up drain stopper, shown in left figure, has just been removed. Shown on right is removal of hair collected against sides of drain pipe by pop-up stopper.





➤ Soil-pipe snake requires use of bucket under sink trap.



◀ To remove the drain trap, loosen the drain coupling nuts with an adjustable wrench.

Usually the drain line obstruction is located somewhere along the piping within the walls of the house. And, that is where the snake, which is a long flexible, coiled spring-steel wire with a hook on its end, comes in handy. It will “snake” its way through and around the bends in the drain pipe.

Insert the snake into the drain pipe leading into the wall, twisting it clockwise with the crank handle as you do so. Loosening the thumbscrew on the handle will allow you to feed more of the snake wire through the handle into the pipe and at the same time keep the handle fairly close to the pipe opening. Work the wire in and out of the pipe slightly as you feed it in. If the wire becomes difficult to twist, or if you feel you have hooked something, pull the snake out slowly, continuing to twist the wire in a clockwise direction. Remove any matter on

What to Do if the Drain Clogs

the hook and reinsert the snake working it as before.

Should the snake hit a solid obstruction 12 inches or so beyond the pipe opening and refuse to travel further, you are probably striking the vent fitting. A little in-and-out movement and twisting should send it around the bend of the fitting. If after making the bend, the wire goes in freely for 3 or 4 feet and yet you find no obstruction, the snake is probably going *up* the vent pipe.

When this happens back out the snake to the point where it strikes the vent fitting and try again. This time you may send it in the other direction or down the drain pipe. If the snake continues to go up the vent after several attempts, remove it and disconnect the drain tail pipe going through the wall. You then should be able to see the vent fitting and guide the snake in the right direction as you insert it.

When you have fished out and removed all the waste particles at the point where the obstruction was, you should be able to push the snake freely past this point and be fairly certain the line is now free of the obstruction.

Reassemble the trap piping and flush the drain line with boiling hot water or a chemical cleaner to remove particles still clinging to the walls of the drain line.

Bathtubs. Old style, leg-type bathtubs with an exposed drain pipe under the tub can be cleaned by following the methods described for a sink because the drain pipe can be removed. The obstruction can also be reached with a snake by merely removing the overflow strainer to admit the snake into the drain line. Some tub installations have a gooseneck-type trap which is under the floor and cannot be removed. With such a setup the snake must be forced through the trap bends.

Bathtub drain lines connected to a drum-trap simplify the problems of keeping the drain line free of obstruction. The only dif-

What to Do if the Drain Clogs

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difficulty you may encounter will be in removing the drum-trap cover. A special wrench, which you can borrow or rent from your local plumbing shop, will be needed for the job.

Once the cover is removed, a snake may be run through the lines in either direction—up to the tub overflow strainer or toward the house waste line. If you cannot find the drum-trap, look for an access trap door located in the wall at the fixture end of recessed-type tubs. In some cases the trap door may be located in a closet of the adjoining room. Once you have removed the trap door, all plumbing will be exposed to view so you can work on it.

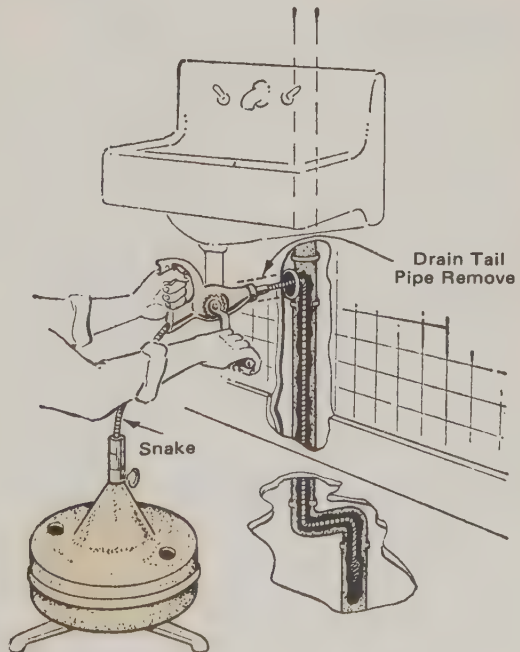
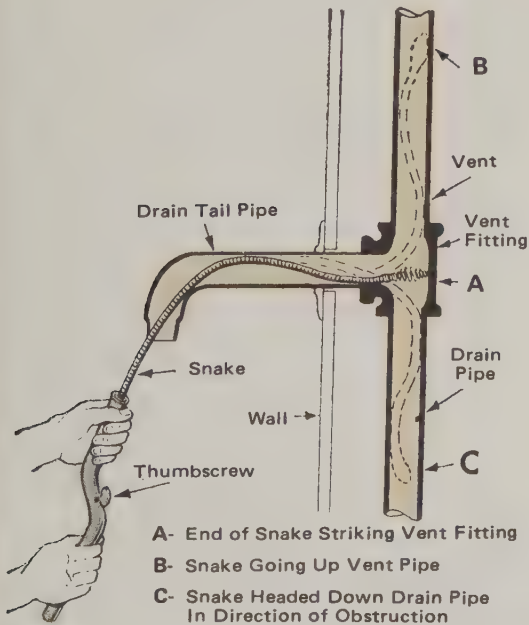
Bathroom water closets. The one thing to remember when the water closet in the bathroom becomes clogged is not to free it by repeated flushings. This only results in the bowl overflowing and a double problem.

▼ A manual snake can be used when the drain tail pipe is left on, as on left, but the Miller Rod House will feed the snake into drain pipe when the tail pipe is removed.

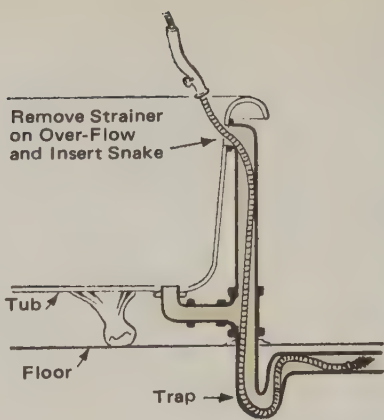
Instead, first try to force the obstruction through with a “plumber’s helper” or force cup. Place it over the outlet in the water closet and work it up and down vigorously, then quickly lift the force cup from the outlet. If some of the water rushes down the drain with a swallowing noise you have probably forced the obstruction through the waste pipe to the sewer. Just to make certain, pour a pail of water down the water closet, and if it takes the water, test by throwing some crumpled tissue in the bowl and flush.

If you cannot dislodge the obstruction with a force cup, the stoppage is probably due to a plastic toy, bottle, small brush, towel or some such object that has accidentally dropped into the water closet and becomes wedged in the closet trap. For this type of obstruction, two tools (closet auger and mechanical fingers) will prove helpful.

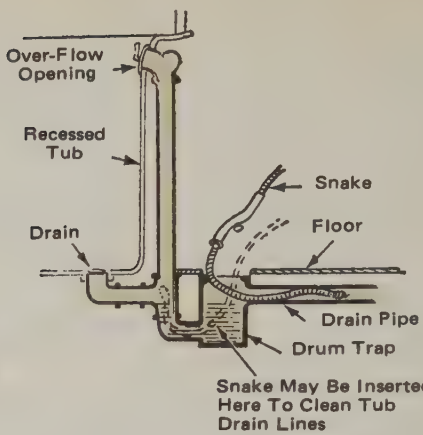
To use the closet auger, first pull the wire “snake” up through the tube by the handle so that only the hook tip protrudes. Place the bent end of the tube in the closet outlet.



➤ The old gooseneck-type traps, as on left, cannot be removed so the snake must be forced through the bends in the pipes. For drum traps, as on right, simply remove the trap cover (located on floor) with special wrench.



Cleaning Drain On Leg-Type Bathtub



Cleaning The Drain Lines Through Drum Trap



CLOSET-BOWL FORCE CUP CLOSET-BOWL AUGER MECHANICAL FINGERS

Then, grasping the tube near the top with one hand, start turning the handle clockwise with the other while slowly forcing the wire snake down the closet trap. The spiral hook at the end of the snake will become entangled in whatever is causing the obstruction and can then be withdrawn, pulling the obstruction with it. Repeat the procedure until you think you have removed enough of the obstruction to be able to flush the rest of it down with a pail of water.

An auger of this type works well for removing obstructions caused by fabric articles such as a towel or diaper or a wad of toilet tissue. The spiral hook, however, is

not much good for grasping a hard solid object like a bottle, plastic toy or ball.

To remove this type of obstruction, the mechanical finger tool is superior. Its 36-inch slender flexible shaft can be forced down and around the water closet trap, and the fingers opened and closed by the knob at the hand-held end of the flexible shaft. The four hooked and sharp spring-steel fingers will grasp rigid plastic objects, as well as fabric and paper.

As a last resort the bowl can always be disconnected from the floor drain fitting to get at the obstruction from the other end of the bowl trap. To do this, first shut off the water supplying the flush tank and, with the tank lid off and your hand on the large rubber flush ball in the tank, allow the water in the tank to flow down into the water closet. If it looks like the bowl is going to overflow, quickly shut off the flow of water with the flush ball. Then ladle the water out of the bowl and into a pail with a tin can, and sponge out the remaining water in the bowl and tank.

If the water closet tank is the type that is fastened to the wall, loosen the coupling nut so that the tank-to-bowl piping will slide apart. If the tank is supported by the bowl, the tank will have to be disconnected and removed first. Then remove the nuts from the sides of the bowl at its base. Some of

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these nuts are covered with a ceramic cap which can be removed by very gently tapping the cap with the wooden handle of a hammer. This will expose the bolt nuts which can be removed with an open-end wrench.

Loosen these nuts alternately, a full turn at a time to avoid cracking the base of the bowl. Then jar the bowl loose with blows from the palms of your hands. Rock the bowl forward and backward over the floor drain outlet slowly to spill out any water left in the trap and set the bowl upside down on some newspapers spread on the floor. By inserting the mechanical fingers or closet auger into the bowl trap you can now reach and dislodge the obstruction.

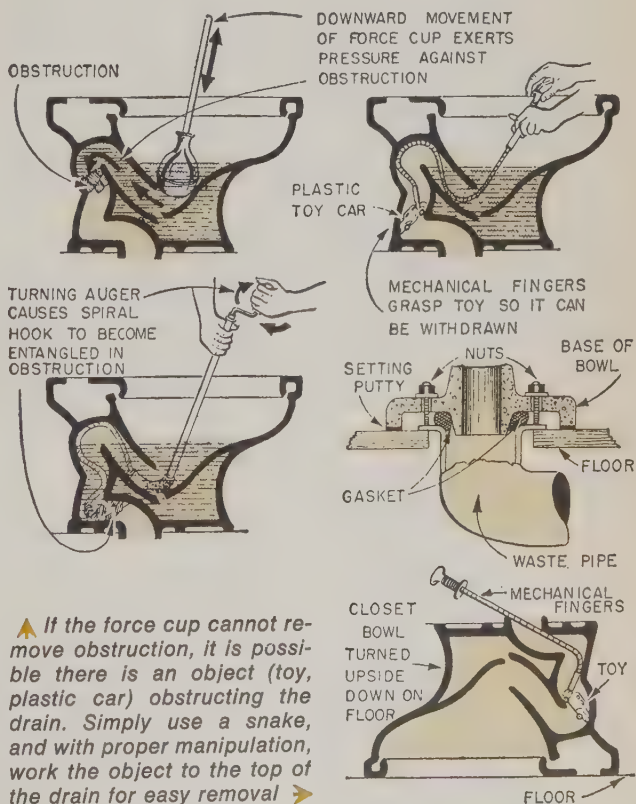
Before replacing the closet bowl, inspect the sponge-rubber gasket used to make a water-tight seal between the bowl and floor flange of the waste pipe. If it was torn when the bowl was removed, replace it with a new one of the same type and thickness. If you do not find a rubber gasket, bowl-setting wax or putty was used to make the seal between bowl and floor flange. Scrape away the old putty and replace it with new bowl-setting putty available at your local plumbing shop. Apply putty around the bowl edges that contact the floor too. After pulling the bowl down to the floor flange with the two closet bolts, scrape away the excess putty that squeezed out around the edges of the bowl. Then reconnect the flush tank, turn on the water and test the fixture by flushing it several times.

Underground sewage drains. All waste water from sinks, tubs, lavatories and water closets in your house is carried away through a 4-inch waste pipe system to the main sewer pipe in the street or to your own septic tank system. The large black, cast iron pipe extending from the floor to the ceiling in your basement is part of this waste disposal system. When this line becomes clogged, the obstruction is usually somewhere in the horizontal run of the pip-

ing beneath the basement floor or underground between the house and the main sewer line.

The first indication of an obstruction in this line is slow and sluggish drainage of the basement floor drain or laundry tubs or overflow issuing from these drains following discharge of a plumbing fixture up in the house. If your town has a combination sanitary and storm sewer system, where the leaders from the gutters are also connected to the waste disposal line, the obstruction could cause the basement to flood due to backup of rain water during a storm.

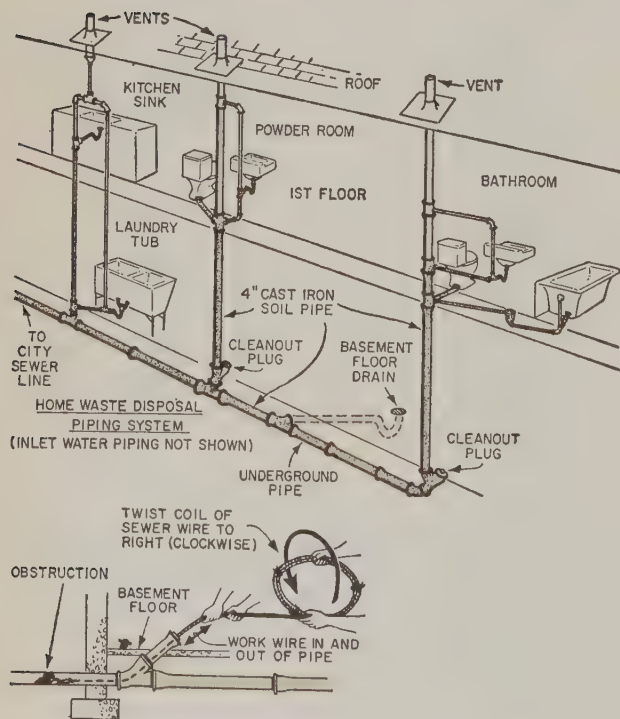
Fortunately, stoppage in waste lines is anticipated when the sewer pipes are laid and one or more cleanout fittings are piped into the system. To run a sewer wire or snake into the line to dislodge an obstruction, the cleanout plug or cover must be



removed. This can frequently be a difficult job, especially if the plug is corroded. First tap the plug around the edges with a hammer and try to unscrew it with an 18- or 24-inch pipe wrench. A 2-foot length of pipe slipped over the wrench handle will give you more leverage. If you can't budge the plug with a wrench, nick the edge of the plug with a hammer and cold chisel, and drive it counter-clockwise until it loosens sufficiently to turn with a wrench.

When you remove the plug, some waste water standing in the vertical pipes may flow out on the basement floor. This is to be expected, so don't be too alarmed since it will only be a few pailfuls. Two types of sewer cleanout wires are available for rodding out the pipes. One is a flat spring-steel ribbon $\frac{1}{2}$ - to 1-inch wide and 50 to 100 feet long with a pointed spear having

▼ When working wire in and out of pipe in basement, increase pressure if it should buckle or seem to get stuck in a cleanout opening.



semispherical rollers on each side. The other is a $\frac{1}{2}$ -inch diameter coiled steel wire snake, similar to the smaller closet auger.

Feed the cleanout wire into the sewer pipe, and keep working it back and forth as you slowly inch it into the pipe. If you suddenly strike a barrier and the wire buckles at the cleanout opening, grasp the wire closer to the opening and continue working it into the pipe with increased pressure. This will often jar the obstruction loose, or send the wire around the pipe bend. Sometimes it is necessary to roll up the snake to within 5 feet of the cleanout; tie or wire the coil in several places and have someone slowly twist the coil while you continue to feed the wire into the pipe. This, too, will help to break up the obstruction or maneuver the wire around a bend in the pipe. Should the backed-up water begin to drain off, keep working the wire back and forth and slowly withdraw it. Remove any material adhering to the wire hook or spear and send the wire in again several times or until the waste water flows through freely.

If the wire hook extracts some tree roots, then your house sewer is probably of clay tile pipe and tree roots have wormed their way in through the joints. This type of obstruction could be very difficult to remove with a hand operated sewer wire and it would be wise to call in a plumbing contractor who has a motor-driven auger made especially for cutting out tree roots in sewer pipes.

Once the roots have been cut out, further root penetration may be prevented by monthly flushings of the sewer, through the cleanout, with a solution of copper sulphate (one pound to a pailful of warm water).

When replacing the cleanout plug, coat the threads with grease or petroleum jelly to make removal easy. Never use a pipe joint compound on these plugs.

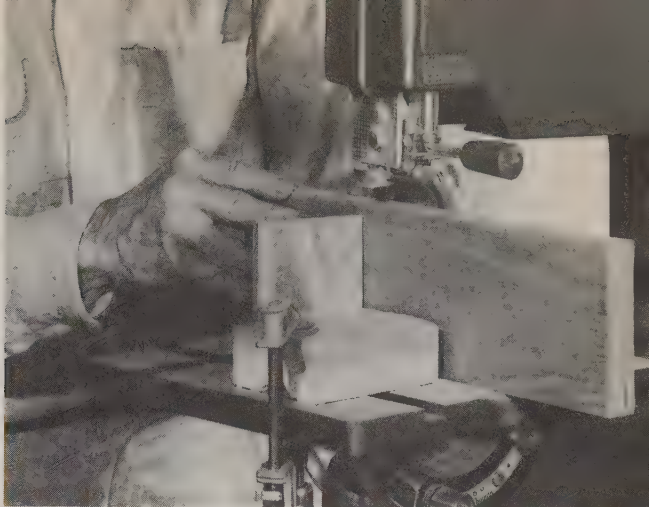
See also: PLUMBING.

Making Cabinet Drawers and Doors

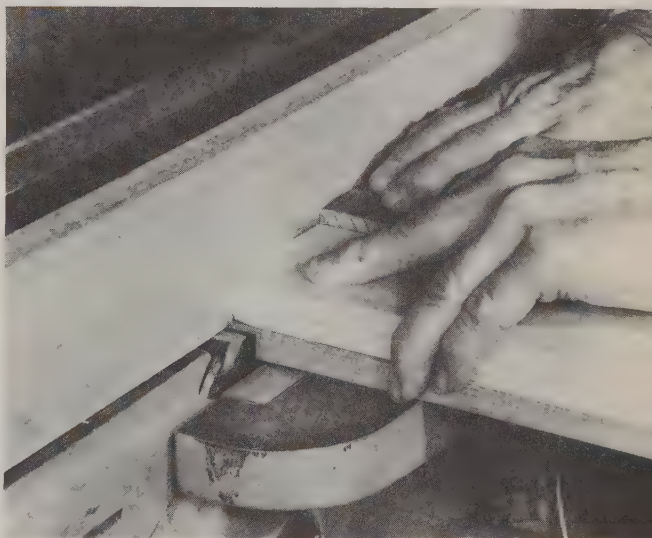
Here's how to calculate dimensions, cut and shape the stock, and assemble it into sturdy cabinet components

THE BEAUTY and utility of a cabinet depends largely on the design of its doors and drawers; and well-hanging doors or smooth-sliding drawers result from a wise choice of materials and careful planning. The tendency of solid wood to shrink and warp makes it a poor choice for doors. Even if quarter-sawed, the better circulation of outside air tends to dry the exposed faces of solid doors, cupping them. In some provincial-type cabinets where the door edges are rounded, cleats are applied to the inside surfaces of the doors, often with screw holes plugged to simulate through-dowels with rounded ends. These cleats may defeat their purpose of preventing cupping unless the screw holes are elongated to allow sliding when the solid wood doors shrink and swell. Such doors need substantial finishing with the same number of coats on fronts and backs.

Where uncleated solid doors are required, mahogany is a good choice. Even though kiln-dried, pile the boards with strips between them for several days to condition them to the same humidity likely to be encountered in service. Rabbeted



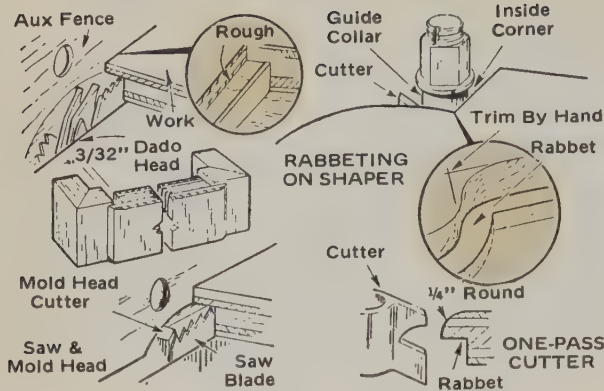
▲ Block up a simple jig with a clamp and scrap wood when making a deep vertical cut like the one shown above.



▲ Cutting a rabbet. A circular saw mounted outside the planing head will give a smoother one-pass cut. The saw should be of the same diameter as the planing head.

edges are preferred on doors because the lips hide the joints with the cabinet frame and conceal the effects of shrinkage.

Ordinary fir plywood is used extensively for built-ins today. However, because the grain tends to rise after painting, the more expensive plywoods with vertical-grained faces are often chosen. Hardboards paint well, but are heavy. Hardwood plywoods



with figured faces are becoming popular, both for doors and drawer fronts, and carpenters make sides and backs for kitchen drawers of plywood when stock solid wood is difficult to get in the thinner sizes. Hardboards are inexpensive and make excellent drawer bottoms. In good furniture, matching solid sides and backs and plywood bottoms are frequent.

Because the "lips" on rabbeted doors lap over the door frame, the door back can be made $\frac{3}{32}$ -inch smaller than the door openings. Rabbets are $\frac{3}{8}$ - or $\frac{1}{2}$ -inch deep to fit standard offset hinges. Check the hinges for dimensions first and make rabbets narrow enough not to rub the knuckles, wearing off paint. Rabbeting can be done in several ways depending upon the type of tools at hand. One of the best ways is to saw the sides. A dado head will cut rabbets in one pass but may leave one side rough and grooved. A combination of a square-edged molding head cutter with a circular saw of the same diameter as the head, shears the plyedge face and planes the other face of the rabbet.

The high speed of a shaper usually guarantees smooth rabbets. Go around successive sides clockwise so that you plane out the slight splintering at the trailing edges. The small diameter of the cutter works well on doors with irregular shapes. Although the cutter will not cut square inside corners, the corners can be cut square with a

hand chisel later. Most rabbeted doors are also face-molded with a quarter-round or some other profile. Cut the mold first, then the rabbet. Combination cutters, or two cutters ganged, shape both mold and rabbet at one pass.

For flush-fit, square edge doors allow about $\frac{1}{16}$ -inch clearance all around. Bevel the lock edges to give swinging clearance. If plywood edges are to be faced with tape wood to hide the plies, make allowance for them. Square-edge doors are often hung on the fronts of kitchen cabinets with hinges attached to upper and lower edges, the side edges forming the front corners of the cabinet. The edge grain should be hidden with tape, which is clipped to length with scissors, pressed into place at the ends, and finally secured by stroking with a medium-hot iron.

Most traditional furniture requires panel doors. Square-edge stock is used for the frames. Make mortises or dowel holes before grooving. If mortise-and-tenon joints are used, make tenon thickness equal to the groove width, usually $\frac{1}{4}$ -inch. Cut the panel slightly undersize and lightly chamfer all around. If a door is doweled, either make stub tenons to fill the grooves at the ends, or plug them after assembly.

Often construction is simplified by making deep grooves in the stiles and using them as mortises. In "stucks," or molded members, the groove is usually the depth of the molding. Strength is gained by gluing in a plywood panel. If a solid wood panel is used, as in raised panels, glue it only at the middle of the ends, leaving the edges free to come and go with humidity changes, but compelling both edges to move, rather than one, as might happen if the opposite edge were held more tightly. With stained finishes, stain the edges of a solid panel under the grooves so that a line of white wood will not show at the edges after shrinking.

Most paneled furniture doors are molded

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on the inner edges of stiles and rails, using a combination cutter that molds and grooves at the same time. The commercial method is to "cope," or mold the rail ends in reverse, so that they will fit over the stile molds. If cope cutters are not at hand, rip off the molding from the stile for the width of the rails, making plain butt joints except for the moldings, which are mitered. Another solution is to miter the joints full width.

A plain panel door may be enriched with applied moldings. A deeply sunken panel can be made by setting the plywood into a groove or rabbet in the back of the door frame using flush moldings around the edges, or rabbeted moldings can be placed around a normal panel, with the face of the molding projecting above the surface of stile and rail. Apply glue and drive the four

fitted moldings into the recess at the same time. Surface moldings can be applied outside at the edges of the door to further enrich the doors. To prevent them from slipping, drive brads into the door, cut off the heads, and file points on them to stick into the backs of the molds.

Meeting edges of doors are often left square but with sufficient clearance bevels. Sometimes they are rabbeted, with the outside joint centered, making the inside one offset. Meeting edges may be molded, or an astragal mold applied, to conceal the joint. The form decided on must be taken into account when planning the overall width of the doors and the size of the stiles.

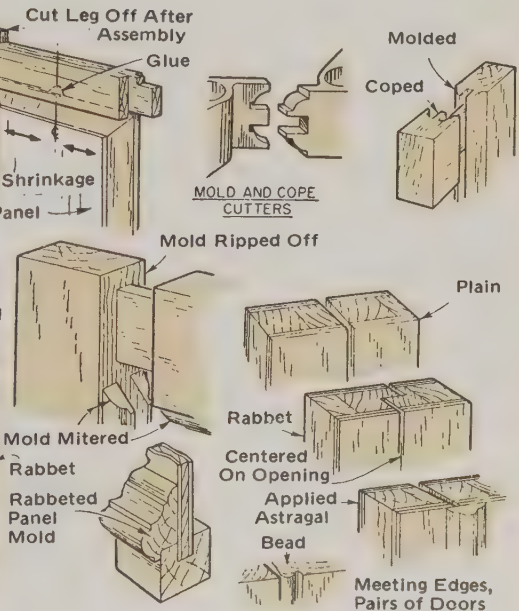
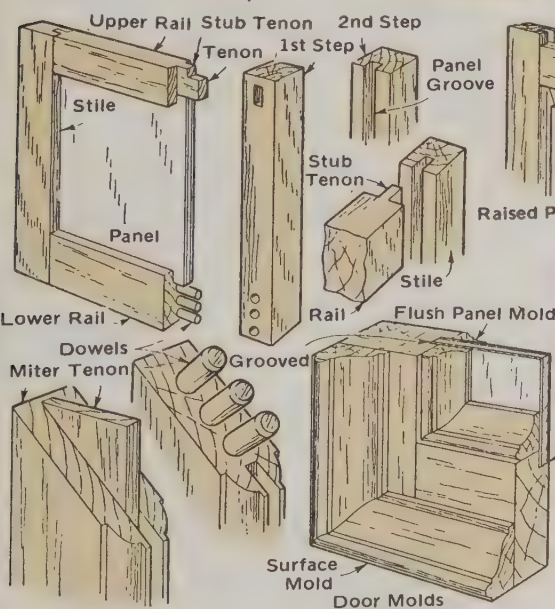
Where swinging doors would be in the way, sliding doors are used. For small doors, pieces of 1/4-inch plywood sliding on the shelf between narrow strips of wood is satisfactory. For larger doors an economical mounting is to embed dowels in the grooved lower edges for sliding shoes moving on a hardwood strip.

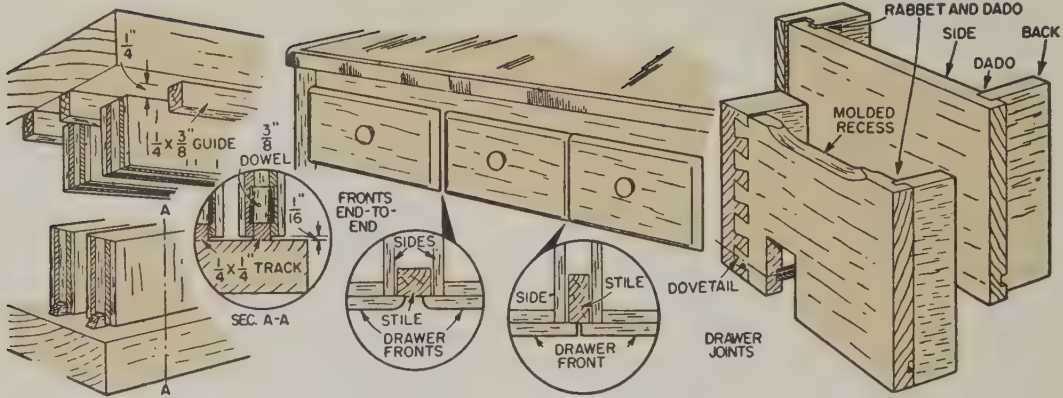
Drawer fronts, like rabbeted doors, are easy to fit. End rabbets on drawer fronts

Determine Angle of Bevel from Radius



Banding with Woodtape

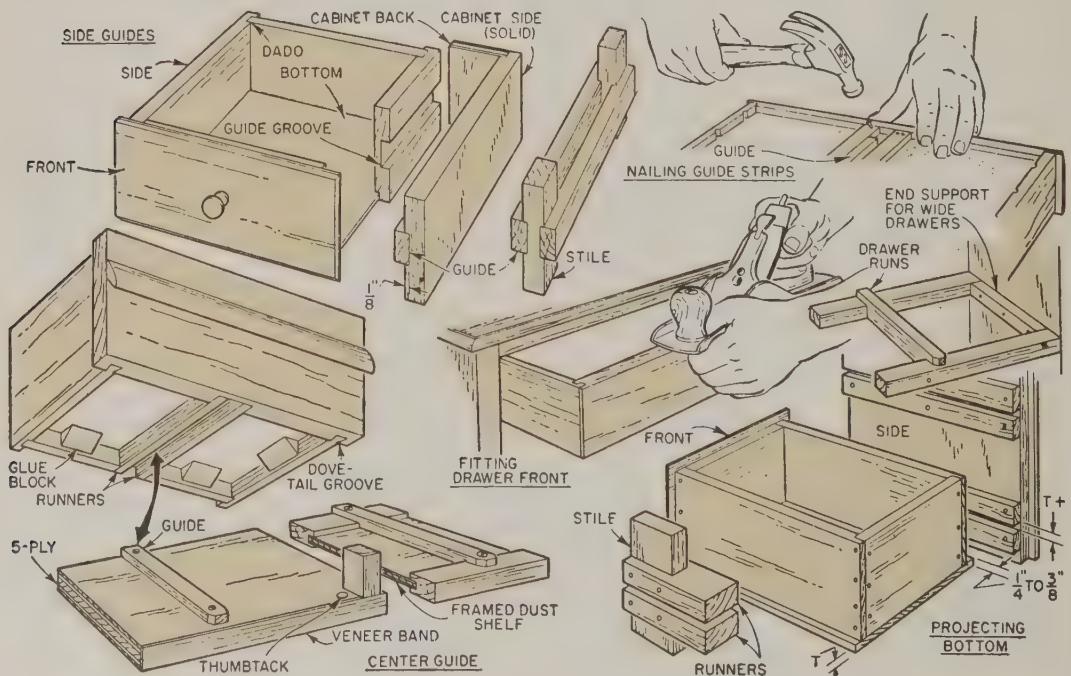




having "lips" are wider than the top rabbets by the amount of the drawer-side thickness plus working clearance. If the cabinet rails are to be hidden, also rabbet the lower edges. Mold the fronts all around, unless rails are covered to give a flush effect to the drawers, in which case only the bounding edges of the group are molded.

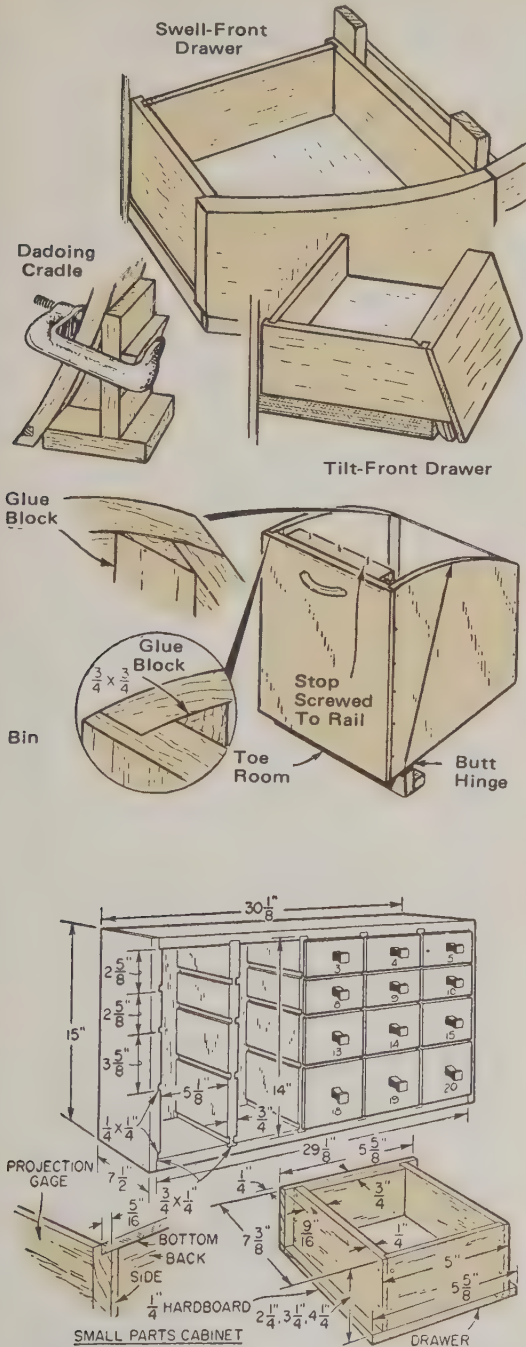
Make the drawer sides $\frac{1}{16}$ -inch less in width than the height of the opening when using plywood and $\frac{1}{8}$ -inch with solid stock.

Nail the sides to the fronts. When sides and front are dovetailed together, arrange so that a tail covers the bottom groove in a drawer front. While back-to-side joints are sometimes dovetailed, more often a dado is used. When front-to-rear space is prized, set the backs in rabbets, nailing both ways if nails are used. Drawer backs in built-ins may reach only to the bottom grooves, so that the bottoms can be slid in after assembly. Square the drawer, nail the bottom into



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the back, and drive a couple of brads into the front. Often glue blocks reinforce the shallow grooves of the sides, back, and front.

Drawer sides are sometimes molded and recessed on the upper edges to reduce friction. Movable drawer partitions can be inserted if the sides are grooved by dadoing or by using a molding head with a half-round cutter.

Drawer side guides are preferred by many craftsmen. They offer good support for the drawer sides, but the danger of jamming is considerable if the drawer is wide in proportion to distance from front to back. With center guides the side width is negligible compared with distance from front to back and guides can be set to close tolerance. A grooved hardwood runner is usually nailed, or even stapled, in the bottom recess and the guide is fixed on a plywood shelf, or a framed dust shelf.

With built-ins, guide strips are usually nailed to the bottom of a drawer. Place the drawer in the opening in proper alignment, run a pencil along one side of the guide, and remove. Brad a strip along the line, set a piece of stock against the strip equal in thickness to the guide, and nail in the other strip. Trim the guide corners at the front. The drawer should close smoothly, even when pushed at one end. Fit flush drawers with about $\frac{1}{16}$ -inch clearance at ends and top. Pull the drawer out a little and dress the top to fit, beveling it in slightly.

For maximum-depth drawers such as filing cabinet drawers, groove the sides to take guide strips attached to the cabinet sides or dividing stiles. Make the guides $\frac{1}{16}$ -inch thicker than the groove depth, to separate the drawer sides from the cabinet. Still more vertical space is saved if the bottoms are projected, to slide in side grooves.

Rabbets and grooves in swell-front cabinets and those with serpentine drawers can be cut at their special angles by holding them in cradles as shown in the accompanying drawing. Paneled drawer fronts are built up much like paneled doors and are fitted like plain fronts. Most rabbeted drawers depend on the lips contacting the

MATERIALS LIST		
Quantity	Size and Description	Purpose
2	3/4" 7 1/2"x27 1/8" pine	top and bottom
2	3/4" 7 1/2"x15" pine	sides
4	3/4" 7 1/2"x14" pine	partitions
10	3/4" 2 1/2"x5 5/8" pine	drawer fronts
5	3/4" 3 1/2"x5 5/8" pine	drawer fronts
5	3/4" 4 1/2"x5 5/8" pine	drawer fronts
20	1/4" 2 1/4"x7 3/8" pine	drawer sides
10	1/4" 3 1/4"x7 3/8" pine	drawer sides
10	1/4" 4 1/4"x7 3/8" pine	drawer sides
10	1/4" 2 1/4"x5" pine	drawer backs
5	1/4" 3 1/4"x5" pine	drawer backs
5	1/4" 4 1/4"x5" pine	drawer backs
20	1/4" 5 5/8"x7 3/8" hardboard	drawer bottoms



cabinet front to act as drawer stops. The front ends of center guides act as stops for flush drawers. In heavy drawers for indus-

trial use, bumpers should be set behind the drawers to prevent damage to fronts from heavy impacts.

Large bins should be made of 3/4-inch stock. Cut the tops of the sides to the arc of a radius equal to the opening height less 1/8-inch for clearance. The front can be lipped, or a substantial stop screwed to the underside of the rail above, after installation. If the bin is to contain powdered material, put continuous glue blocks on inside corners to strengthen the joints and eliminate sharp corners.

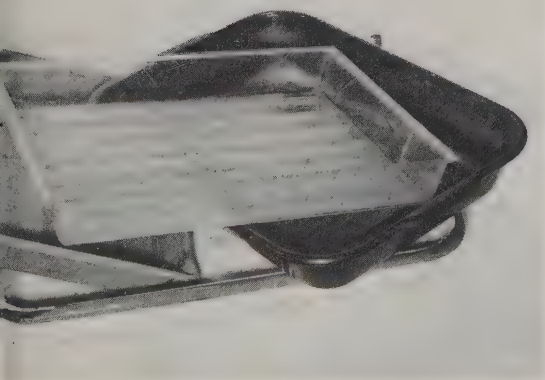
A compact cabinet of drawers for holding small parts is indispensable in a shop. A simple assembly of 20 drawers that can be quickly built is shown in a drawing. Dado the ends and partitions for drawer runs, gaining sliding clearance by spreading the blades of the dado head with paper washers. Cut the drawer bottoms net size and smooth the edges with a sanding disc to provide sliding space. Center the drawer bottom, during assembly. Coat all parts with a plastic sealer and rub the drawer edges with paraffin.

See also: CABINETS; FURNITURE, INDOOR; TOOL TECHNIQUES; WOODWORKING.

Instant Drawers for Your Workshop

Discarded trays, pans, muffin tins or what have you, can be converted into handy storage space

THE LARGE VARIETY of shapes and sizes of plastic, aluminum, sheet metal, and porcelain trays that are found around the home and are easily obtainable in hardware and department stores usually have a lipped edge. They offer extraordinarily simple, effective, and ready-to-use under-table or shelf drawers for a number of storage needs in the shop. Don't throw away such a pan or tray that is no longer usable for its original purpose—it can be put to new and valuable use as a drawer.



▲ *This discarded porcelain tray is given a new and useful lease on life as spare-parts drawer.*



▲ *Rabbeted 1x2 makes a simple drawer guide, or two pieces of scrap can be used in similar manner.*

◀ *Trays are economical at original purchase price; more so when they've been discarded.*

➤ *Driving and removing screws around the house is fast and effortless with the aid of a portable drill. Some drills will actually thread the hole for you.*



Making the Most of Portable Electric Drills

Knowing the size and type of portable drill for a particular job, the types of drill bits and their uses, and how to make your own drill attachments will show you why these drills are the most versatile power tools around

THE PORTABLE ELECTRIC DRILL with the various accessories available is, without a doubt, the most useful and versatile portable power tool there is today. Originally intended as a portable power tool for drilling holes, it has developed into a power pack for operating such attachments as: a circular saw, jigsaw, belt or disc sander, grinder, buffer and polisher, and wood lathe. It even operates an air compressor for paint spraying.

New time and labor saving attachments for the portable electric drill are being de-

veloped every day to make it even more useful and versatile.

The size of a portable drill indicates the maximum diameter of drill bit the chuck will take and bore a hole through mild steel. Larger diameter drill bits for boring holes in wood have 1/4-inch shanks to fit the popular 1/4-inch portable drill. Home workshop electric drills are available in 1/4-, 3/8-, and 1/2-inch chuck sizes and are duty rated as *light*, *standard* or *heavy duty*. The price of a drill varies with its duty rating and this rating depends largely on the design of the equipment's motor.

Light duty drills are for intermittent use only. Since their motors are wound with small diameter wire on the field and armature coils, these drills tend to "heat up" if overloaded or used continuously for long periods of time. Overheating eventually breaks down the insulation and the drill motor shorts out. When used intermittently they are entirely satisfactory since the motor has a chance to cool between jobs, thus prolonging the life of the drill.

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Standard and heavy duty drill motors are wound with larger diameter or gage wire than the light duty drills, which in turn requires larger aluminum cases to house the motors. Heavy duty drills also have larger ball bearings, hardened gears and shafts, and more rugged construction throughout. All this adds up to higher cost. The standard duty drill, however, will run continuously under an average load with small temperature rise and take short period overloads without harm.

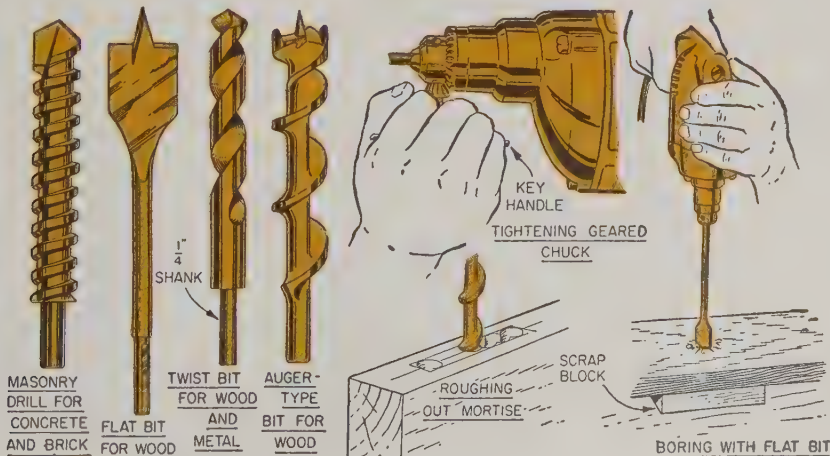
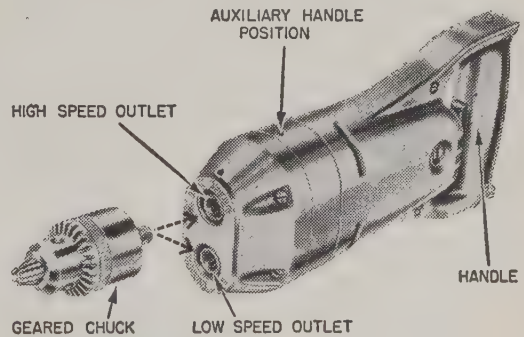
The standard duty drill is probably the most satisfactory for home workshop use because of its construction, price and ability to operate drill attachments for longer periods of time than required to merely drill a hole. The heavy duty drill, although satisfactory for home use, would be uneconomical for occasional use because of its higher price.

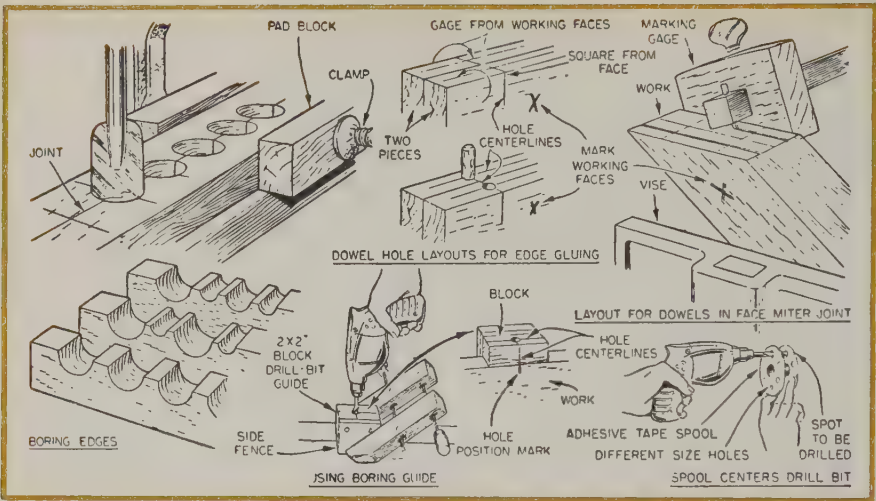
The type and speed of the drill chuck must also be considered when purchasing a drill. Choose a geared-type chuck operated by a key if the drill is to be used with attachments. Drill-chuck speeds vary from no-load speeds to 500 rpm for 1/2-inch drills to 1600 to 2800 rpm for 1/4-inch drills. The correct speed for a particular drilling job depends upon the size of the drill bit and the type of material being drilled. Most 1/4-inch drill attachments op-

erate best at a speed of about 1500 to 2500 rpm. Drill speed will drop 200 to 300 rpm when a load is placed on the drill bit or attachment.

Since it requires having two drills (a 3/8- or 1/2-inch slow-speed and a 1/4-inch high-speed) to handle all the jobs around the house, some manufacturers make a two-speed drill for home workshop use. The drill-speed reducer is another way of making a 1/4-inch drill do the work of a large slow-speed drill.

Drill bits are available in a wide variety of types and sizes for boring holes in almost any material. The common twist drill can be used for boring both wood and metal and is especially useful where there is danger of boring into hidden nails or screws, as frequently occurs in building repair.



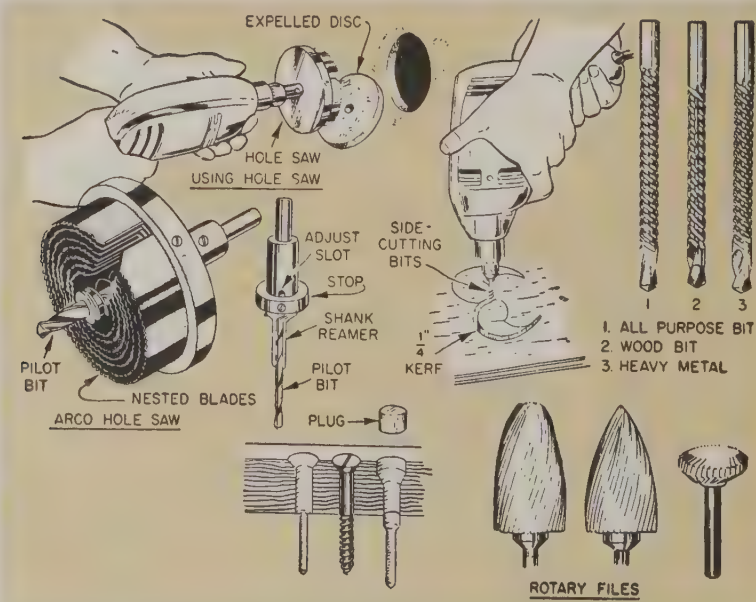


Auger-type bits have shanks of a fixed size in a set regardless of hole boring size. These cut fast and clean and can be accurately centered by inserting the points at intersecting lines or in dimples made by indenting the wood with a center punch or awl. Flat bits, also extend the diameter capacity of a drill. To prevent splintering the underside of the wood when the drill bit breaks through, rest or clamp a block

of scrap wood under the work piece. Flat bits are excellent for fast rough boring. When drilling holes larger than 1/4-inch with a 1/4-inch drill, keep the drill-feed pressure light and "nurse" the drill through the material to prevent overheating the motor.

Boring is adaptable to ornamental as well as utilitarian work, where gallery edgings are being made. Clamp two strips of

➤ Cut out discs with a hole saw, which is held on center and guided with a pilot bit. Cut intricate curves with a side-cutting bit. Rotary files work into odd corners and places hard to reach with ordinary tools.



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wood together, using the joint for a center line. Various patterns are possible with variation of bit size and spacing. Bore a series of holes with an auger bit to rough out a mortise.

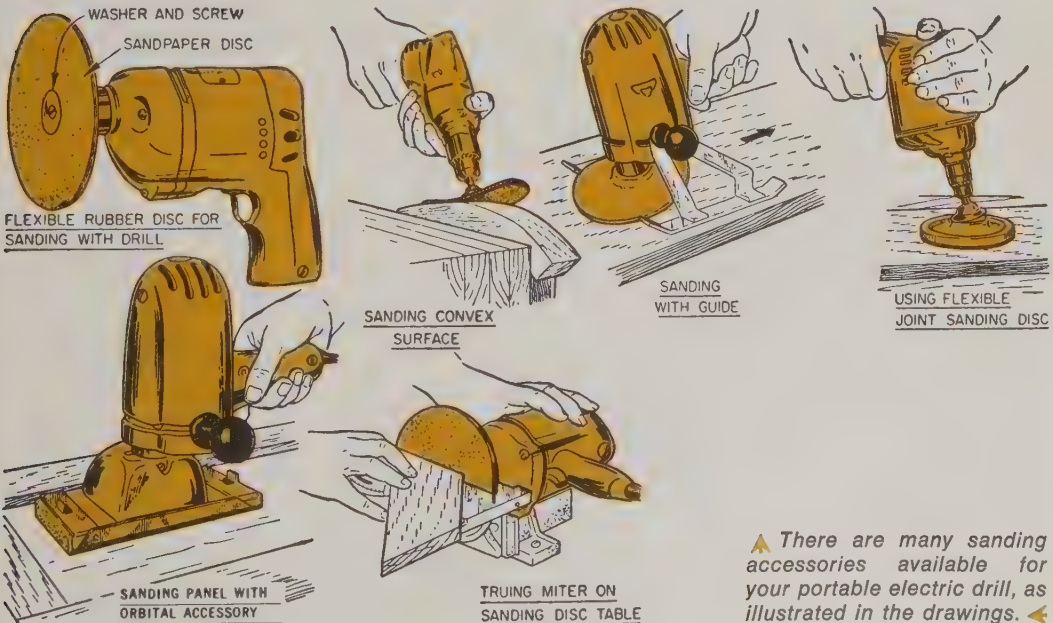
Since boring with a portable drill is ordinarily freehand as to direction, careful layout should be made in doweling jobs. For edge-to-edge gluing, clamp a pair of boards in a vise, working faces out, and square across both to locate the holes. Gage center lines from the working faces, and dimple the intersections with an awl. Layouts for dowels in mitered frames are made in a similar manner.

Commercial doweling guides are useful; however, a home-made device can be used. Here a guide hole is bored square in a 2 x 2-inch block and a side fence then fastened to the block. In use, align the hole centerline on the block with the centerline on the face of the work. To aid in drilling holes 1/4-inch diameter and less square and perpendicular, make a guide for the drill bits by boring several different-size holes through both flanges of an empty adhesive

tape spool using a drill press. To use, locate the correct-size hole in the spool directly over the spot to be drilled, insert drill bit and bore hole.

A hole saw saws out discs instead of reducing the material to shavings as a boring bit and makes it possible to cut 2 1/2-inch diameter holes with a portable drill. The nested blades are removable so that the one of the diameter selected can be used alone by inserting it in its groove and locking with a screw. The hole saw is guided and held on center with the pilot bit. Apply pressure until the cutter has sawed through the board. As the saw is withdrawn, the center spring ejects the disc.

A side-cutting drill bit converts your power drill into a router-like tool that will cut intricate curves, making a 1/4-inch wide kerf. First bore a hole with the side-cutting bit, then force it along the layout line with the bit in the waste wood. Adding a push and pull, or sawing action is helpful, when cutting diagonal to the wood grain. The sides of the hole can be beveled by tilting the bit at the appropriate angle.



▲ There are many sanding accessories available for your portable electric drill, as illustrated in the drawings. ◀

First aid to driving screws is the screwdriver bit which bores a pilot hole for the threaded part of the screw, a shank hole in the piece that is to be screwed down, and countersinks the hole for a flat-headed screw all in one operation. Such a bit may have a stop adjustable for height so that the hole can also be counterbored for a wooden plug, either to be dressed flush to hide the screw, or to appear as a false dowel rising a little above the surface. To use such bits, tack or clamp the parts together and bore in the usual manner. Bits are available for the various sizes of wood screws. To drive screws rapidly, the speed reducer can be used. Several types and sizes of screwdriver bits are available for use with this attachment.

For use in carving and working wooden surfaces into various shapes, rotary files are useful. Made in many shapes and sizes, they will work into odd corners and places hard to reach with ordinary tools; and while most efficient at speeds higher than those of portable drills, they cut rapidly and smoothly with light, deft touches. Hold the drill firmly with both hands when working and touch the wood gently, feeding against rotation. Work with or across the grain, according to need.

The most generally useful disc sander for portable drills is a flexible rubber back-up disc faced with an abrasive sheet which is held with a screw sunk into the depressed center. Insert the shank of the sanding-disc arbor in the drill chuck, and sand by pressing a part of the disc against the work while rotating. With the soft backing there is little tendency to gouge in, and the strokes feather off well, leaving no offsets. Cross scratches are removed by finishing with fine sandpaper. On broad work a better job of surfacing is done if the machine is mounted on a sliding base and locked at a slight angle. Stroke toward the raised side of the disc.

The flexible sanding disc is useful for

Making the Most of Portable Electric Drills

sanding checked and scaling paint before repainting. For this work use an open-coated paper which will not clog as readily as closed-coated sandpaper. For polishing purposes, lambswool bonnets are provided to draw over the rubber backing.

A flat sanding disc with a flexible joint is suitable for freehand use with a portable drill because the shank accommodates itself to small variations from the vertical of the holding position. So used, the gouging is reduced and a flat surface is easily obtained. An oversize sandpaper disc used on the metal tends to reduce sanding laps.

Sanding-disc tables, adjustable for tilt and provided with small miter gages, can be set for accurate sanding of small work, correcting miter joints and hopper cuts. Move the piece across the face of the disc while holding it firmly against the miter-gage head to avoid uneven cutting due to the more rapid travel of the sandpaper near the outside of the disc. Vibration-type sanders, with straightline or orbital motion, are also available as attachments for drills. The rapidly moving pad sands smoothly and will work up into corners of panels and other recesses. A little more pressure than the weight of the machine is needed to give a bite.

Many of the advantages of a drill press are obtained by clamping a portable drill to a bench stand. Held rigidly in the yoke, the drill is raised and lowered with a lever, the drill moving in a vertical line. The depth of boring is regulated by clamping the yoke at the required height, or in some models, by locking a collar below the yoke, on the column, to limit travel. Before drilling, press the switch-lock button to free both hands for holding the work and feeding the machine. A hinged wooden table can be built for boring at an angle.

Veining or routing is done by chucking a suitable bit, locking the yoke at cutting depth and moving the work under the bit, guiding along the line. Because the bit

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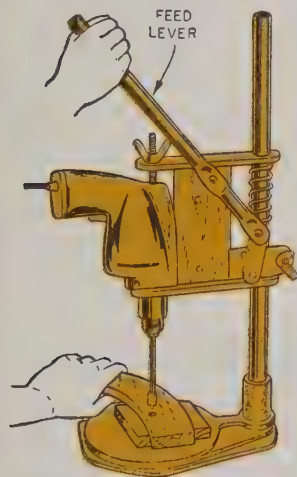
tends to back away from the cutting side, slide the work from left to right over the base being careful to keep the guide line at the far side of the bit at all times.

The circular saw attachment has many of the features of a standard portable saw, and is used like it, guiding the indicator along the line, or tacking or clamping a straightedge to the work for the edge of the bottom of the attachment to slide against. By the use of a dado arbor, which has a tilted washer and socket joint arrangement for a wobble saw, a cutting blade is made to sweep from side to side, cutting a wide kerf or groove.

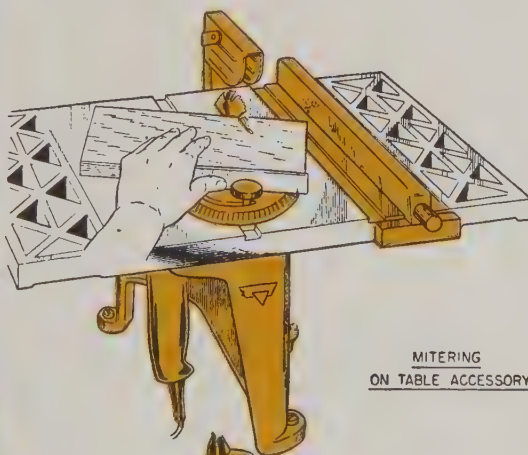
Saw tables, complete with rip fence, miter gage, and table extensions, turn the portable drill with its saw accessory into a standard table saw. For this work the miter gage, swiveled to the required angle, guides the work past the blade. When setting the rip fence for cutting a board



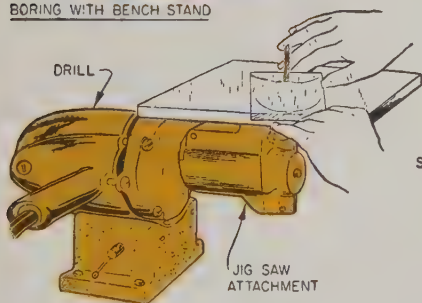
▲ Beading cutter, included in most electric drill shaping sets, is ideal for smooth decorative molding cuts.



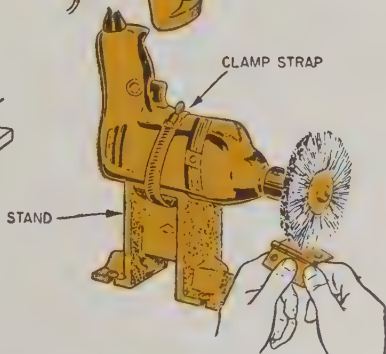
BORING WITH BENCH STAND



MITERING
ON TABLE ACCESSORY



JIG SAW
ATTACHMENT



CLAMP STRAP

STAND



Making the Most of Portable Electric Drills

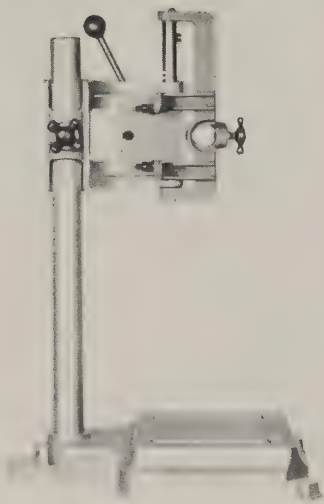
◀The wide variety of bit attachments available include large hole cutters which give you accuracy as well as a clean cut, unobtainable with a manual saw.

to width, measure the distance from the fence to a blade tooth which is set toward it. Usually, in ripping, 1/16-inch extra width is allowed for jointing the edge.

For scroll work, the jigsaw attachment is used. Strapped or otherwise clamped in place, start the saw and, if making an inside cut, tilt it forward to allow the tip of the blade to cut through the piece. Then follow the line, cutting in the waste. If smoothing is needed, cut 1/32-inch inside the line. Circle cutting is accomplished by pivoting the guide rod on a point. With a table attachment the blade projects upward, the cutting following methods used with a regular shop jig saw with saber blade. Inexpensive stand supports that convert the portable drill into a bench-mounted power tool are available for most drills. With the stand fastened to the bench or vise, an abrasive wheel can be mounted on the drill arbor for grinding and sharpening knives and tools; a buffing wheel can be substituted for polishing, or a wire-brush wheel for cleaning rusted metal parts.

See also: POWER TOOLS; DOWELS.

➤Drill presses increase the versatility of portable drills. By holding the drill in place and guiding it in a straight line, the press enables you to make precision holes with the simple pull of the lever.



DRILL SPEEDS FOR HIGH SPEED STEEL TWIST DRILL BITS							
	Mild Steel	Tool Steel	Hard Cast Iron	Copper Bronze Brass	Steel Forging	Wood	Masonry Concrete Stone
1/16	6000	3000	4000	8000	3700	12000	
1/8	3000	1500	2200	5000	1800	7000	
3/16	2000	1000	1500	4000	1200	4000	
1/4	1500	750	1000	3000	900	3000	700
5/16	1250	600	900	2800	750	2500	600
3/8	1000	500	700	2600	600	2000	500
7/16	875	425	600	2400	500	1800	400
1/2	700	400	500	2200	400	1600	300

NOTE: For carbon steel twist drills, reduce drilling speeds by one half.

Make Difficult Drilling Jobs Easy with a Machine

Using a drill press or radial arm saw for boring will save you time and give you precision not possible by hand

THE EASE AND ACCURACY with which holes can be bored in wood with a machine is in striking contrast to boring holes with hand tools. The machines support the work at the required angle and guide the bit, limiting its travel if necessary.

Machine bits are smooth-cutting, long-lasting and can endure much sharpening. Auger-type bits, unlike the hand variety, have either brad points to eliminate self-feeding or interrupted threads that aid in feeding a hand power-drill while permitting easy disengagement. For large holes use multiple spur bit, either solid or with removable blades, or circle-cutters.

Screw-hole bits are made to fit definite sizes of flat head screws. The bit is run in to the stop, drilling the pilot hole into which the threads bite, the shank hole, and the counter-sink for the head in one operation. For the occasional odd-sized hole or the seldom-needed bigger holes, an expansion bit with the square on the shank cut off works well. File most of the threads from the points and run the machine at slow speed. High speed may bend such a bit at right angles, with dangerous effect.

Many drill presses are equipped with interchangeable spindles, one carrying a geared chuck capable of mounting bit shanks of various sizes, and one with a

solid chuck taking ½-inch shanks. Combination machines use slip-on geared chucks and adapters.

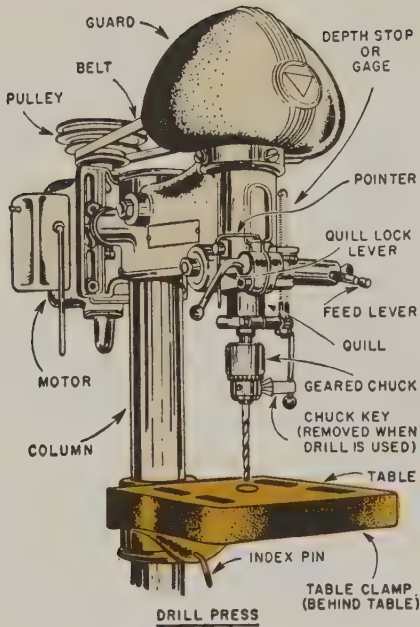
Most holes are bored square into the face of the board. To set up a drill press, grip the bit in the chuck, rest the work on a block, and raise the table to bring the piece close to the end of the bit.

The block under the work protects the underside from splintering as the spurs cut through. If a number of holes are to be bored, set the depth gage to stop quill travel as a hole is completed. This protects the block from quick wear and also saves time. If you are using a drill press, touch the bit to the block and run the washers down against the stop lug. The upper nut locks the setting. If you are using a combination machine, touch the bit to the board, turn the collar to read the thickness of the board, and lock it. Depth can be read directly on a drill press by setting the quill scale pointer.

In general, small holes can be bored as fast as the feed lever is drawn down. In production work this can amount to a downward plunge of the handle, a flick upward, and a quick shift of the work to the new position. Feed is usually slower in hard woods than in soft, or if very smooth holes are desired. Small work being bored with large holes should be held in position by the setup.

Since one advantage of using a machine for boring is to save time, a setup for quick locating of holes is essential. When one or two holes are to be bored, lay out by measurement and center the bit on the intersection of the lines. For edge boring a series of holes, clamp a strip of wood to

drills: see hand tools
drills, electric: see power tools
dripping faucets: see faucets
drive gear assembly: see engine



▲ The basic advantages of boring by machine are speed and precision.

the drill press table or an auxiliary fence on the rip fence of the combination machine, and bore the first hole. Mark the position of the end of the piece on the fence and lay out the hole spacing on the fence. Bringing the end of the work to these marks locates the holes. As an alternate method, tack a guide block to the wooden fence where it will graze the edge of the first hole when the work is positioned for boring the second. Thereafter, set succeeding holes according to the block to locate a new boring. While convenient this setup has one drawback. Any error in locating the second hole is repeated in the spacing of all the holes.

If a line of holes lies at an angle with the edge, set a miter gage to guide the work on a combination machine, or use a fence and an angular block with a drill press.

Blind holes are regulated as to depth with the stop, eliminating need of an under-block. Counterbores, for sinking bolt heads

flush, are bored before drilling the bolt hole, thus giving support for the bit centering point.

Surface boring with radial saws can be done on boards narrow enough to go under the saw arm. Substitute a wide board for the regular fence, placing it at the back of the table and wedge it against the column to prevent springing under boring pressure. If the holes are to be bored near the edge of the piece, rest it on a block of suitable thickness. Use a bit with a left-hand twist, held by an adapter.

Edge boring on a combination machine is done in the horizontal position, with the board lying on its face and the rip fence taking the thrust. Spacing holes in a series is done with the setup described earlier. On a radial saw, prop the work at a suitable height. Holes are at right angles to the edge or at an angle, depending on the swing-setting of the track arm.

The usual method of end-boring with a drill press is to swing the table to the vertical, clamping the work to it. Thickness spacing is done by swiveling the table on the column. An improvement in this setup is the cleated board. The body of this fixture is a piece of vertical-grained wood bored with a series of slanting holes to take the $\frac{3}{4}$ -inch dowels projecting from the support cleat. Thread the bolt, sunk flush, with its washer and wing nut, through the table center hole and secure with a hardwood fork between the washer and table fins. Rest the end cleat on the edge of the drill press table. Locate the support cleat at a convenient height by inserting the dowels in the holes, and stand the work piece on it. In precise work, clamp a vertical fence strip to the fixture for the edge of the work to contact.

The fixture can be used on a combination machine in the horizontal position, with it and the work positioned against the miter gage. For long boards use a clamp instead of the support cleat.

Make Difficult Drilling Jobs Easy with a Machine

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For end boring with a radial saw set the motor axis parallel with the fence, lock it at boring position, and feed the work against the bit. A simple supporting stand is valuable here, with the heavy, high fence set against or clamped to the regular fence. Gage depth by means of a block clamped to the stand.

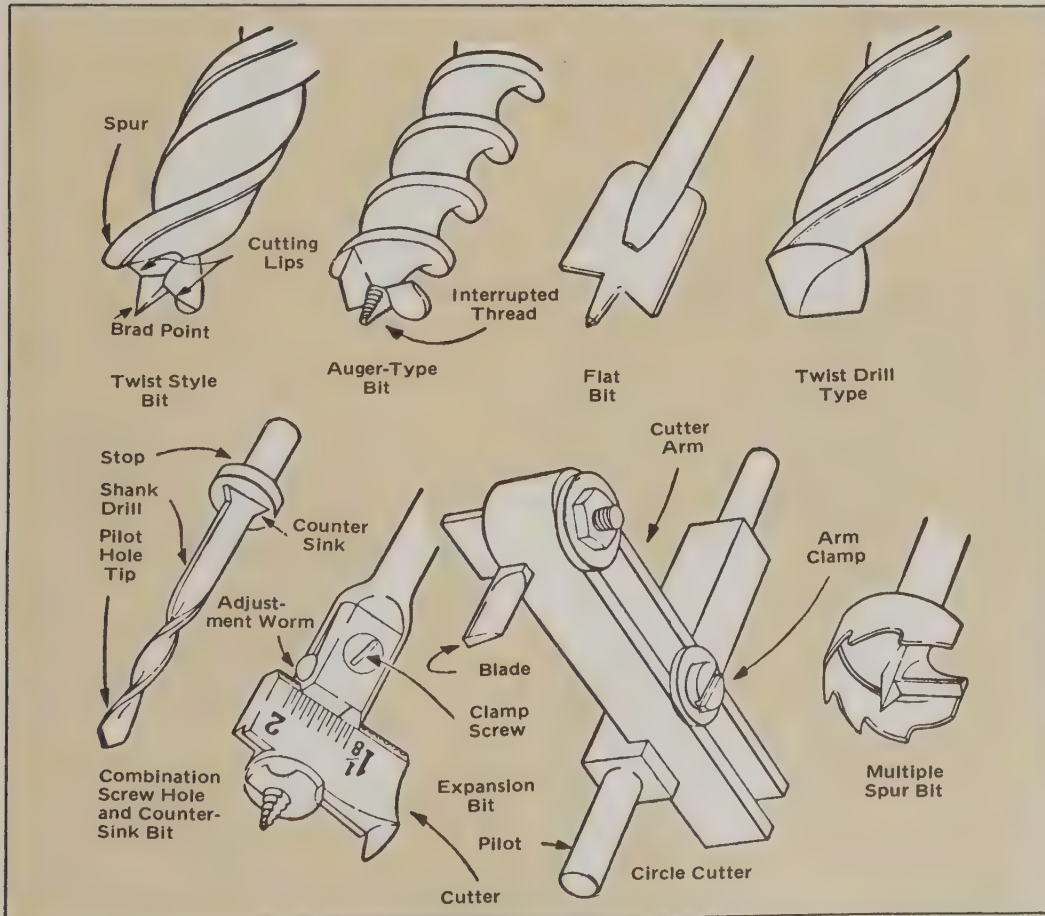
Machine boring is best for making doweled joints, so that the faces align after assembly whether dowels are accurately centered or not.

When boring the ends of rails, place the face against the table, the working edge

against the miter gage with its extension, and use a spacer strip to separate it from a stop clamped to the table. When the hole is bored, remove the spacer, slide the rail up against the stop, and bore the second hole. If all parts are of equal thickness, and the holes are perfectly centered, turn the rail end-for-end, placing the opposite face against the table, and repeat. Use the rail end as a pattern for marking the stile edges for boring.

Dowel holes in face miters are often laid out as for hand work. To bore them on a combination machine, clamp the piece to the vertical table with the miter aligned with the upper edge of the table. Support the edge against the miter gage, which is anchored with a stop block. The work is

▼ Machine bits are smooth-cutting, long-lasting and can endure much sharpening.



prevented from giving under boring pressure by a block clamped to the rip fence.

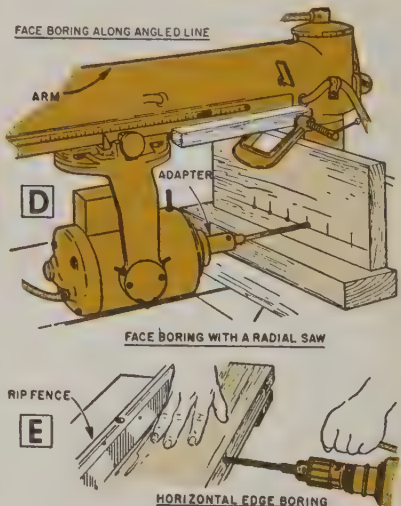
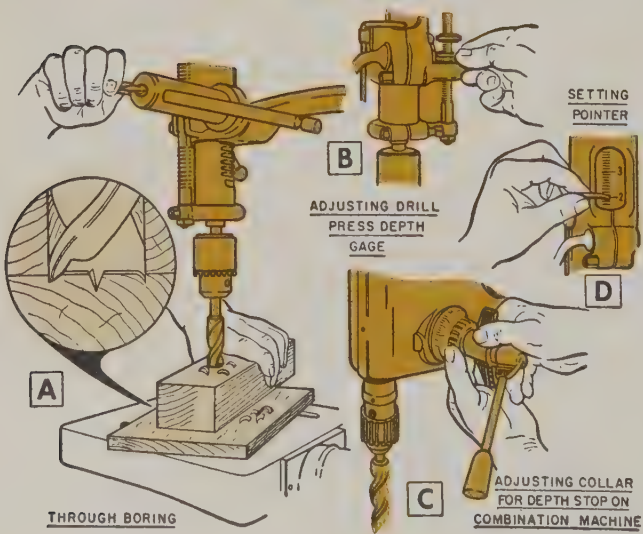
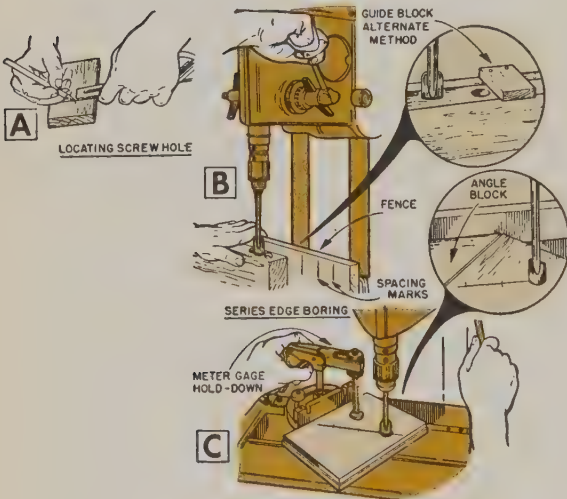
When boring dowel holes in mitered edges, as in the side of a column, tilt the table until face of miter is level. In this way, the table will support the piece while the fence takes the thrust. Since the column of a drill press would interfere with the boring of pieces of any length when the table is tilted, an auxiliary table must be built to hold the piece crosswise. The drill

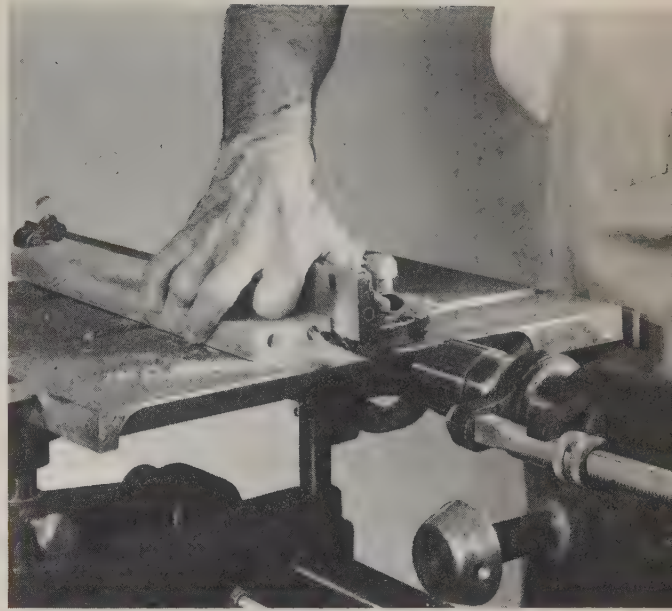
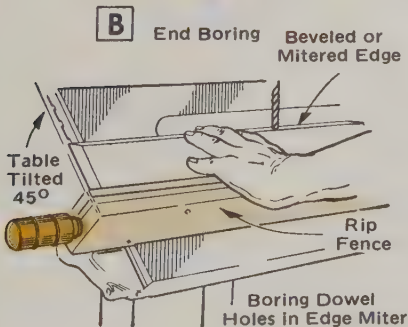
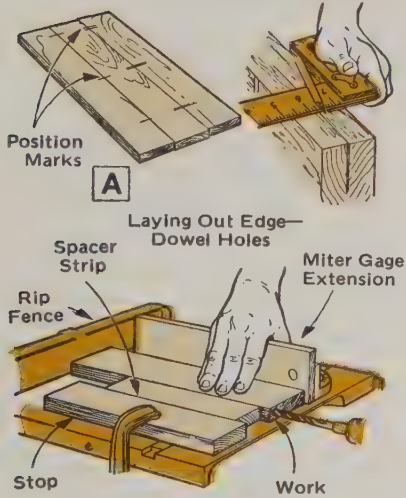
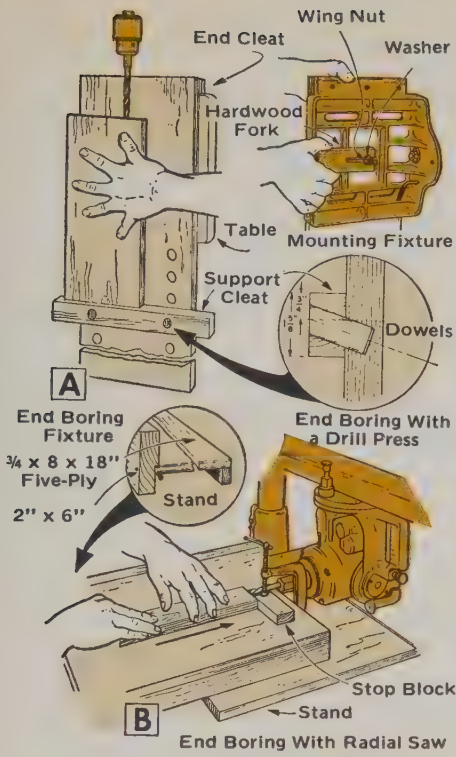
press setup for boring dowel holes in mitered ends consists of a projecting block clamped to the table edge to align the miter. A clamp keeps the piece from slipping, and swiveling on the column centers the hole. A simpler method is to use the end-boring fixture supported on the tilted table of a combination machine. Use the miter gage to align the work, pushing it to the new position for boring another hole.

A vee-grooved block is useful for boring diametrical holes through wooden rods. The rip gage used with the tilted table serves the same purpose with a combination machine.

To bore half holes in the edge of a board to receive shelf-cleats, or just for ornamentation, clamp a strip to the edge with a cleat across top and bottom. With this assembly against the fence, clamp a guide strip against the forward edge, and slide the assembly between to align the holes. If the half holes are to be full semicircles, center the bit on the joining of the two pieces. Otherwise, center it to one side of the joint.

To bore holes around a circle, either on a disc or some other shape, pivot the work on the center of the circle, using a bolt through the piece or a nail filed to a point





▲ Boring dowel holes in a face miter. Group the holes toward the back edge to increase dowel length.

▼ Boring end miters with a drill press. A fence and spacer strip can be used to align the work instead of the edge block.



BORING SPEEDS	
Size of Bit	Speed RPM
Up to 1/2 in.	3500 up
1/2 to 1 1/4 in.	3500-1300
Over 1 1/4 in.	1300-600
Note: expansive and multi-spur bits may burn if used over 600 rpm.	

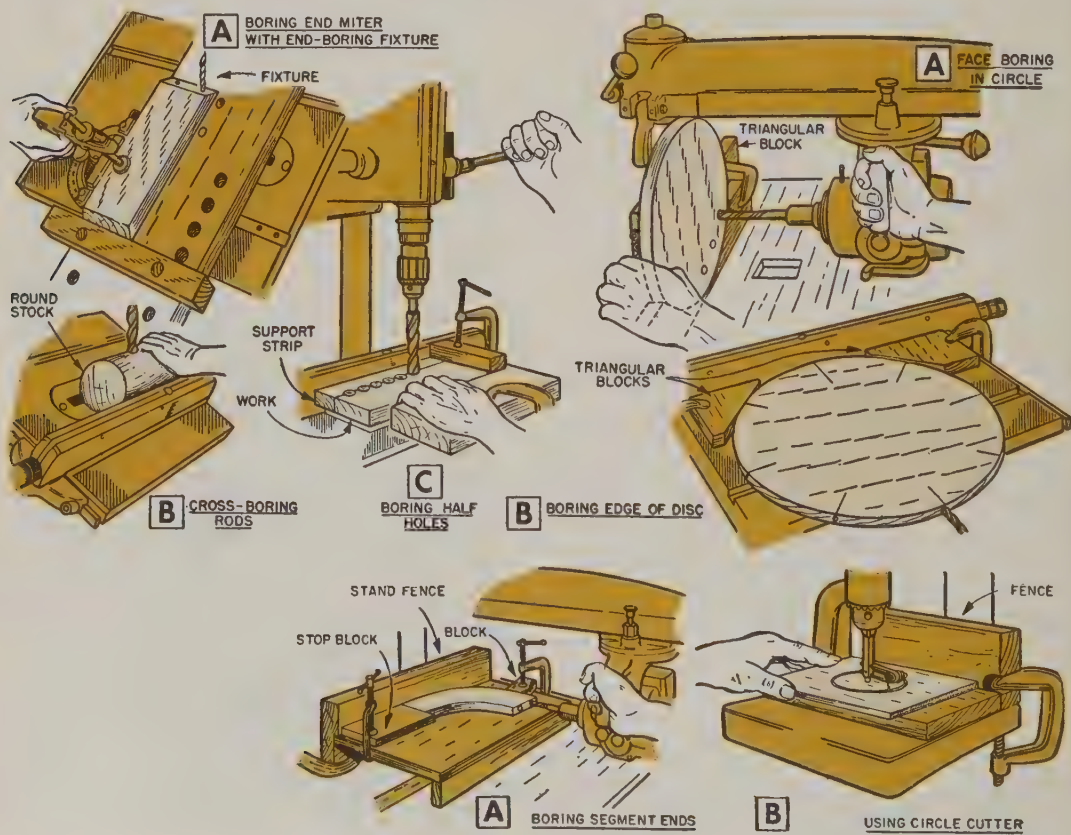
and driven into an auxiliary table. If the bolt or nail hole is objectionable, clamp a couple of triangular blocks to fence or table, according to the machine, forming a vee to receive the disc. Discs are limited in diameter to those that can project far enough under the arm to position the bit.

Fellies of spinning wheels and similar structures require dowel holes in the ends of the segments for assembly. This setup for use with a radial saw can be used with

either drill press or combination machines. A fence, together with a stop block clamped to it or the table top, and another block to keep the near end of the segment from swinging outward, holds work for boring. The end being worked must be at right angles to the bit. Bore the same hole in corresponding ends of each segment, shift the blocks to locate the next hole, and then reverse the setup for boring the other ends.

When using a circle cutter, clamp the fence to the table, bore a pilot hole in the piece for the tool pilot, and rest the piece on a block, one edge against the fence to prevent it from turning. The size of the circle is determined by the extension of the arm carrying the blade. Run the tool at low speed.

See also: CABINETS; DOWELS; TOOL TECHNIQUES; WOODWORKING.



➤ Face grooving on a drill press can be done by clamping a strip of wood to the table to act as the rip gauge. For larger boards an auxiliary table can be bolted in place.



Routing with a Drill Press

Use your routing bits to cut rabbets, grooves and mortises, carve bowl interiors and relief lettering, do jobs virtually impossible with other machines

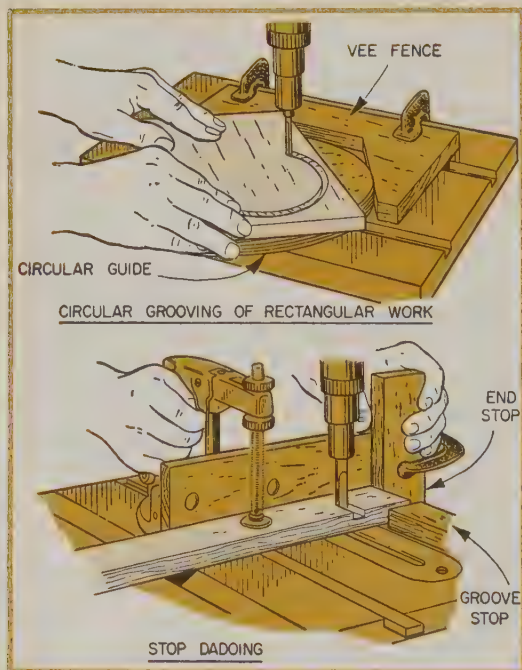
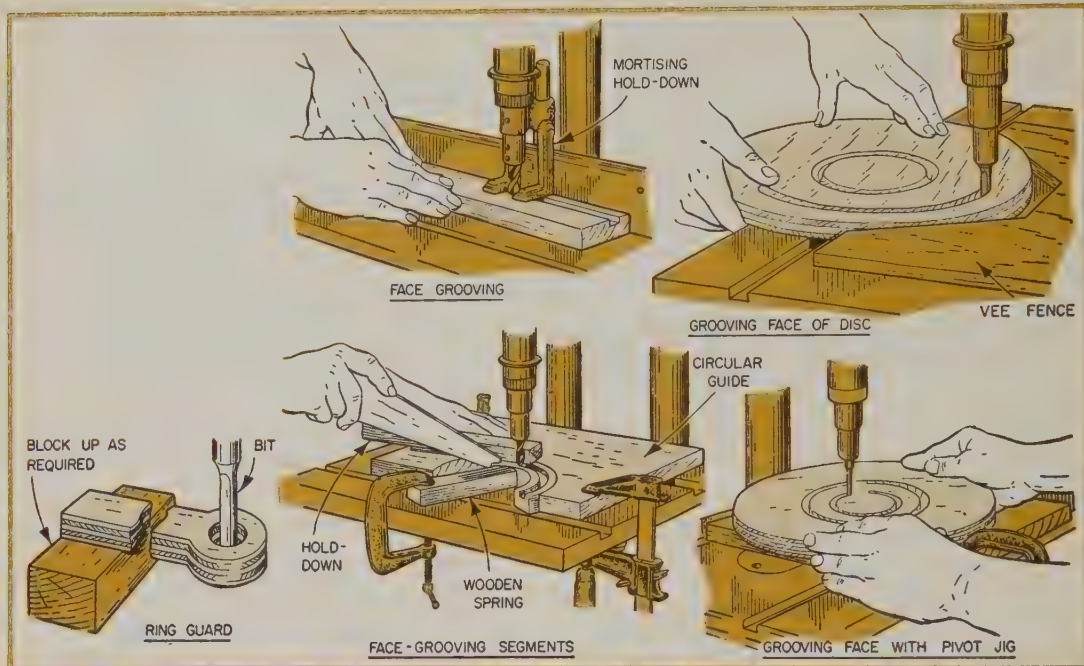
ROUTING INCLUDES a variety of operations ranging from shallow grooving, such as veining, to the hollowing out of trays and boxes. The cutter is a specialized bit capable of boring and of cutting side-wise; and while the best work is done with high-speed machines turning up to 20,000 rpm, a drill press operating at 5,000 rpm will perform fairly well and handle many jobs in the home workshop that could hardly be machined in any other way.

Use solid chucks or adapters rather than geared chucks to hold the router bits. In much of the work your fingers can be shielded with a ring guard made from plywood and clamped to the machine table with a block beneath it to raise it above the work.

While the router bit is ordinarily second-best to a dado saw for grooving and dadoing, it is superior in certain special cases. Often it will take care of such a job when it is undesirable to change the

setup of a circular saw during another run of work. In face grooving, the edge of the board slides against the rip gage, which is set approximately on the table and is then adjusted to exact position by racking the table in or out. On a drill press this setup can be duplicated by clamping a strip of wood to the table to act as the rip gage; or for larger boards an auxiliary table could be bolted in place.

For rigidity set the table high enough so that the quill need be extended only slightly more than the depth of cut. If a twist-type router bit is used, provide a hold-down, such as that provided for mortising, as there is a tendency for the work to climb with this bit. Set the bit for a depth of cut of about $\frac{1}{8}$ -inch at a pass, locking the quill in position. The cutting edges of the bit, rotating toward the fence, tend to hold the work against it if the piece is fed from left to right. To stop the groove at the left end, simply feed toward a limiting mark on the work, or one on the fence indicating a stopping point for the end of the piece. If the board is too long for this, clamp an auxiliary fence to the rip fence that is long enough to carry the mark or a stop block, which terminates the feed automatically. This setup is best when making duplicate parts.



Stopping the groove at the right end is accomplished by lowering the quill at the right place, locking it, and feeding to the

right as before. A stop block to the left of the work will position it for the start of the cut. This is the setup for routed mortises. The rounded ends of the mortise can be squared by hand with a chisel, or the edges of the tenon rounded to fit.

If you wish to groove a segment of a circle, the setup is similar to that for straight work; a board sawed out smoothly to the radius of the outer edge of the segment acting as a fence. The inner edge could be run against a disc for a fence, although usually the first is better. A narrow wooden spring clamped to press the work into the curved fence is helpful.

Concentric grooves in a disc are cut with a shaping setup, such as clamping a board with a vee-notch to the table and rotating the disc in it. Such a fence accommodates discs of several diameters, and requires a minimum of labor in the making. Lower the bit into the work and feed by rotating clockwise. If a straight-bit router is used a hold-down is not needed, but the work must be held firmly on the table with the

Routing with a Drill Press

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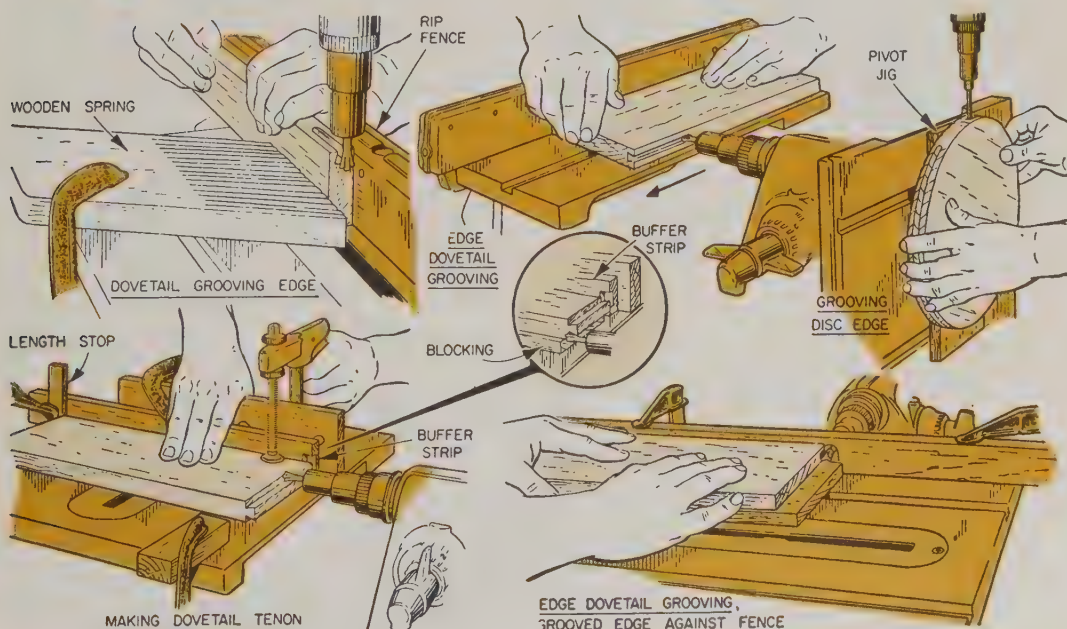
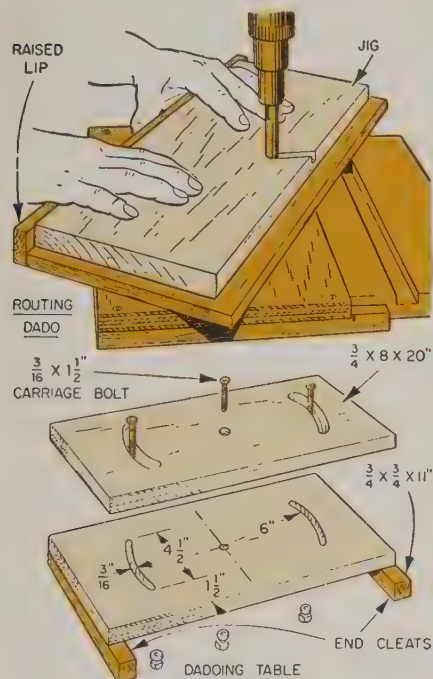
hands, for any lifting causes the cutter to dig into the bottom of the groove.

The same operation can be done with a pivot jig. Set the pivot pin—a dowel or bolt to fit a hole in the underside of the disc,

or a nail to drive into the work—into a board which forms a table for the disc. Clamp it to the table where the bit will cut a groove of proper radius.

With a modification of either of these arrangements, circular grooves can be cut in rectangular pieces or other forms. Attach the work to a disc with nails driven into the underside, or pivot like a disc. Since the routings are centered on the disc in the first case and the pivot in the second, care must be exercised in locating the work.

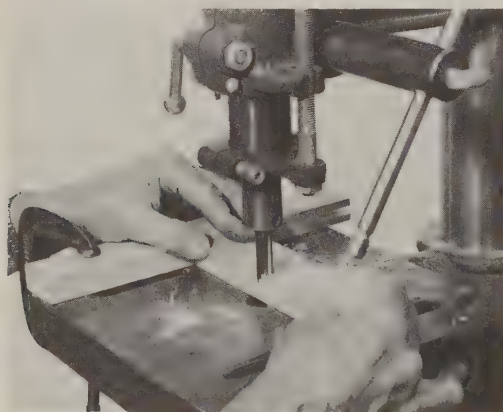
A setup for stop dadoing is also possible. While holding devices built into the miter gage are useful, it is good to clamp a block on the miter gage extension to locate the end of the work-piece. This prevents creeping of the board and also positions the dado for one or a hundred pieces. If the dado extends full-width of the work, place a strip of wood between the board and the miter gage extension to prevent damage to the extension. To stop the dado at the near edge, clamp a block on the table for the far edge to strike against; to locate the end of a stopped groove at the forward edge,



clamp a block between the miter gage and the operator.

Swiveling the miter gage cants the dados, as for tilted shelves. With a radial saw the angle is supplied by swinging the track arm. Lay the board on the table against the fence, clamp a block against the left end, and one against the near edge to resist splintering. Radial saws require the use of left-handed router bits.

Dadoes in wide boards are best handled with a sliding jig. In its simplest form it consists of an auxiliary table with end cleats bearing against the table to guide it in sliding. A raised lip on the near edge fits against the edge of the board to be dadoed. In the drawing this jig is elaborated by using two boards with curved slots channeled to sink bolt heads and nuts flush. The upper board is bolted square or at an angle, depending on the direction of the dado.



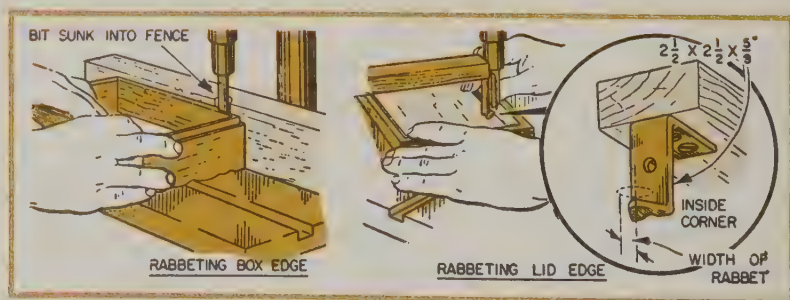
▲ Wide notches should be roughed out with auger bit, then smoothed with router.

Clamping the work on the jig prevents creeping. Stop blocks can be used for stop-dadoing.

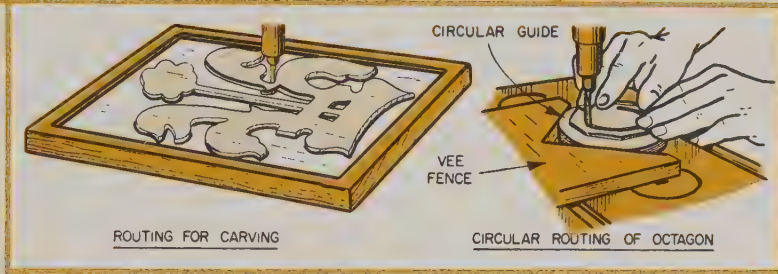
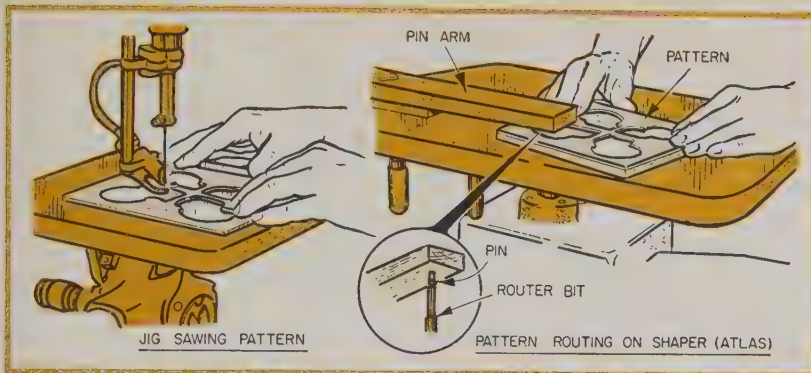
Edge grooving of a narrow piece is conveniently done by sliding the opposite edge on the table and the face against the rip-fence. Such a groove is useful where movement in the joint is necessary, as on the ends of a drawing board where the dovetail locks the ends of the wide glued-up board into end cleats to prevent warping. Glued only at the center, the board is left to swell and shrink with changes of humidity.

A horizontal setup of the combination machine is best for wide boards, since the board rests flat on the table. If the edges are parallel, slide one against the rip fence, the exact location of the cutter being obtained by moving the quill and locking it. If a dovetail groove is to be cut, make it no deeper than the tapered section of the cutter. The difficulty of this setup is that the groove is parallel with the opposite edge, regardless of any taper that may be present in the board. If a fence is used to guide the edge being grooved, the shape or direction of the opposite edge makes no difference. A straight wooden strip is notched to pass the cutter and adapter and clamped to the table parallel to the edge. Rest the piece to be grooved on another board in order to give clearance to the adapter above the table. Then adjust the table for centering the groove and the quill for depth of cut.

A pivot-jig setup is effective for edge-



Routing with a Drill Press



grooving of a disc. It can also be used with the machine in a horizontal position. A vee-fence is also suitable. A setup with the bit horizontal provides for grooving the inner edge of the segment. A convex guide for the inner edge to slide against provides for routing the outer edge.

End grooving of a wide board can also be done. Stand at the back of the table and feed the work under the cutter with the rotation of the bit, a poor practice for most routing but good in this case because the cutting edges—moving downward—shear the shoulder cleanly, instead of splintering the surface as might happen with the customary feeding if the cutter were a little dull. Turn the board over to cut the other side of the tenon. The thickness of the tenon and its fit with the groove is regulated by raising or lowering the table. Driving fits or free sliding fits can be obtained by shimming the work with strips of paper, permitting very fine cuts.

If the edges of the board are slightly out of parallel, or the miter gage setting is not exact, the shoulders of a dovetail cut in

this way will not align with each other and will be offset at one edge or the other. The method shown in the inset overcomes this difficulty by keeping the same edge against the miter gage. After cutting the upper side, raise the work-piece by putting a board beneath it so that the cutter can pass between the table and the underside of the work, starting the cut at the near edge. This requires recessing of the buffer strip before the work-piece is set against it.

Setups for rabbeting are similar to those for grooving. However, as only a portion of the router bit is exposed for cutting, the bank is usually sunk into an auxiliary fence. The bottom of a box, from which the lid was sawed after assembly, can be rabbeted to leave a raised inside ledge. After setting bit projection and depth, feed the box from left to right, rabbeting one side. Withdraw the box, place the adjacent end against the fence, and rabbet it. Continue around until the job is done. With a similar setup the face of a board can be rabbeted, the edge sliding against the fence.

By moving the fence back so that the

box lid side can be run between it and the cutter, its inside face can be rabbeted. Lower the bit to depth after placing the edge of the lid against the fence and feed from right to left. The work must not shift from the fence or the cutter will gouge into the box sides.

A better setup is to use a guide against the inside. Bend the end of an iron inside-corner bracket outward across a screw hole and grind it to a rounded point. Screw this to a strip of wood and clamp it in the position shown with a block underneath to make it clear the box lid. Set the tip of the guide under the end of the router but back from the cutting edge to provide for the rabbet width. Any movement away from the guide reduces the width of the rabbet, which can be trimmed with another pass.

A useful form of routing is freehand work. In carving, much tedious work is avoided by routing out the background of a carving, leaving the raised parts for the chisel. Bore into the background the required depth, or for a cut $\frac{1}{8}$ -inch deep, lock the quill, and trace around the outline. Slight bumps left can be trimmed off after the remainder of the background has been removed with the router. Inside angles are cut out with chisels.

Routing is useful for making relief signs, the name being raised or sunken. Sunken lettering to post the homeowner's name along with the house number makes for an interesting project. Sketch the name in script on a smooth board, allowing for the width of the groove by drawing two lines, place on the drill press table, and bore in to a depth of $\frac{1}{16}$ - to $\frac{1}{8}$ -inch. Cut between the lines, and where it is impossible to proceed without backing up raise the cutter and move to another point where a new cut can be made. Sand off the feather raised by the cutter and paint in contrasting colors.

Carved boxes can be hollowed quickly

by routing. Remove the waste by boring repeated holes with a large bit, after which the sides are trued by sliding them against a rip fence with the cutter inside. Plane the bottom by moving the box around freehand under the router bit.

Free-form trays are hollowed by free-hand routing. Rotary files are excellent for final shaping and rounding of corners, the tray being slid around on the table or tilted, according to circumstances.

Pattern routing is a means of clean cutting in decorative veining and grooving or of actual piercing of work. Lay out the design on $\frac{1}{4}$ -inch plywood and jigsaw. Smooth the edges, as any irregularities are reproduced in the finished work. Tack this pattern to the piece to be grooved. If brad holes are objectionable, make pattern and blank oversize enough that the nails can be driven in the margins that will be trimmed off later as waste material.

In a blank metal table insert set a guide pin by screwing a threaded rod the same diameter as the cutter into a tapped hole, or glue a dowel into a wooden insert or an auxiliary table. Make the height of the pin slightly less than the thickness of the pattern, and center the pin accurately with the cutter. To rout the design place the pattern over the pin with the work-piece on top, lower the router to the depth of cut, and move the assembly around with the pin sliding against the pattern cutout. If the work is to be pierced, lower the router bit to cut through the piece.

The superior speed of a shaper makes it better for this work than the drill press. Screw an adapter onto the spindle to carry the router. The setup is opposite to that of the drill, the pattern being on top where it is easily seen, with the pin set into an arm above the work. In production work the arm should be a flat spring, permitting it to be bent upward when the pin is inserted in a new hole.

M.E.

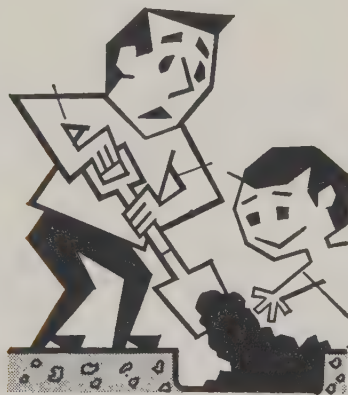
See also: POWER TOOLS; WOODWORKING.

How to Patch a Driveway

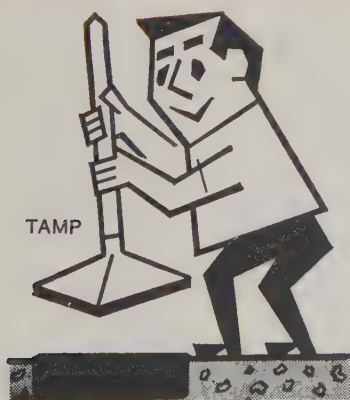
Fill those potholes
and cracks before they become
major problems



▲ To patch potholes and large cracks in asphalt drives, cut loose material down to a solid base, using an old hatchet. Cut walls vertically and square corners of hole, then wash hole with clear water and a stiff brush.



▲ When hole or crack has dried, overfill it with patching asphalt to about one inch above the surface. Temperature should be around 50° for best results. Patching material will be more workable if kept warm before using.



▲ Tamp down the asphalt patch until it is level with the drive (another method is to drive a car back and forth over the patch). If required, apply additional asphalt to the patch to bring it level with the driveway.



▲ Reseal and recolor small cracks by first scrubbing them with clear water, then letting them dry, then applying asphalt sealer with a large rubber squeegee. Allow 8 hours for drying, 48 hours before driving on it.

driving safety: see safety, home and driving
drop leaf coffee table: see tables
drop leaf server: see servers
drowning: see safety, water
drown-proofing: see swimming

Servicing Drum Brakes Yourself

You can check and repair your brakes safely and save ten dollars for every hour you work

THERE IS NO MYSTERY about how a car's brakes are supposed to operate. And it does not take a master mechanic to spot the most common brake ailments or to actually make the necessary repairs and adjustments.

Working carefully, you can do a safe, sure job of brake repairing, and count on a savings in labor costs.

To determine whether your brakes need servicing, first check out their performance with this simple road test (performed in a deserted parking lot, if possible). While driving in a straight line at 15-20 mph, try a quick stop.

See if any of the tire marks in the gravel are heavier than others or if the rear wheels have swerved out of line. Try the same test again, but ease up on the steering wheel as you stop. If the wheel spins to one side, you know the brakes are not equalized and are dangerous on slippery roads. Now let the car coast and listen to the brakes while they are applied and release slowly. Carefully note any noise or faulty operation and then check the symptoms on the table for possible



causes. You can locate the defect exactly by eliminating the most easily checked and repaired causes first.

Pedal clearance. Let the car sit a few minutes after the road test and then push the brake pedal down hard and hold it there. Then see how much clearance or *reserve* you have between the brake pedal and the floorboard. If this clearance is less than three inches, check the fluid reservoir at the master cylinder to make sure the fluid is within $\frac{3}{8}$ -inch of the threads on the filler neck. This reservoir is usually part of the master cylinder, or else it is a small tank connected to it by a line. If the fluid level is low, refill with a heavy-duty, nationally available-brand that is guaranteed to mix with all other brake fluids. Then repeat the pedal reserve test.

Free play test. Next, test the brake pedal for *free play*. Apply just enough pressure on the pedal with your fingers to move it. The pedal should move about $\frac{1}{2}$ -inch before you feel the resistance of the master cylinder piston. If there is less, the piston is not returning to its normal "brakes-off" position and is blocking the

drum sander: see floors

dryer, clothes: see washer and dryer

dry iron repair: see irons

dry sink: see early american

Servicing Drum Brakes Yourself

compensating port. Consequently, some of the fluid pressure may be retained, preventing the brakes from releasing completely. Adjustment for free play is usually made by loosening the lock nut on the push rod linkage between the brake pedal and the master cylinder. Then adjust the travel of the rod by turning it until the correct amount of free play is obtained. On some older Ford cars, the free play is adjusted by turning an eccentric bolt.

Adjusting the brakes. Virtually all American cars for some years have had self-adjusting drum brakes.

With this system, a cable is attached to the anchor pin, run around a flange on one of the brake shoes and attached to a lever which bears up against the familiar star wheel adjuster, described later.

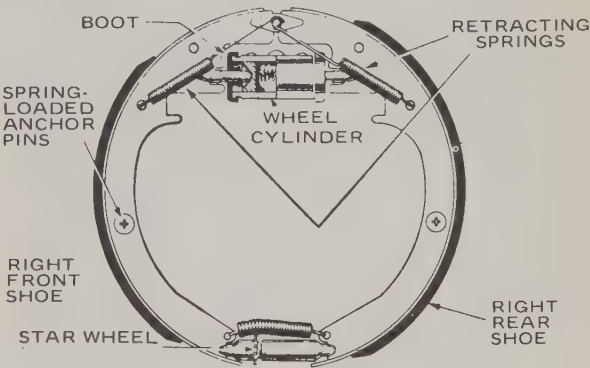
When the car is operating in reverse and the brakes are applied, the outward movement of the shoe tugs on the cable and this actuates the lever, which moves the star wheel adjuster. Normally, no manual adjustment is necessary.

If, however, the system becomes corroded and freezes, it must be disassembled and penetrating solvent applied, or the parts need replacement.

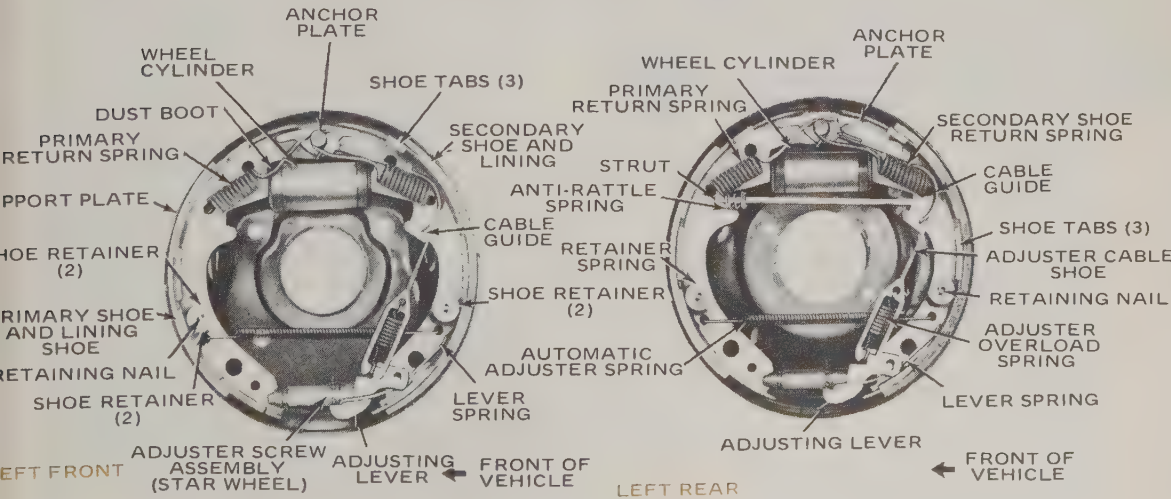
Older cars and some high-performance cars of recent years have manual adjusting brakes, and they are described here.

The most common system, to which the self-adjusting mechanism has been added, is the star wheel.

To adjust this type of brake, raise the wheel, remove the oblong rubber rust plug from the back plate and insert a screwdriver or brake adjusting tool. By working the tool in a prying motion, you will be able to turn the star wheel inside



▼ Modern self-adjusting drum brake is shown, below, with all components labeled. Note self-adjusting assembly which includes cable, guide flange on secondary shoe and lever assembly to actuate star wheel. Compare with manual adjusting setup, above, in which you see the simple star wheel and a tensioning spring over it. ▲



the drum until the shoes are expanded to their limit and the wheel is locked tight. Then, by prying in the opposite direction, back off the star wheel just enough to let the wheel turn freely. Apply and release the brakes several times, and check again for shoe drag by rotating the wheel. If there is any drag, readjust until the wheel turns freely. Be sure to replace the rubber plug.

The second type of adjustment is an *eccentric cam*. The cam adjustment may

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be made at the back plate with a wrench or through a hole in the front of the drum using a screwdriver. The adjustment is the same regardless of the method used to turn the cam. Working on one shoe at a time, rotate the cam until the brake shoe is tight against the drum and the wheel is locked. Now back off the cam just enough to allow the wheel to turn without the shoe dragging. Repeat the operation on the other cam and brake shoe and then check as with the star wheel system.

Hydraulic line inspection. Now with the car indoors, continue your inspection by getting under it with a flashlight to inspect the hydraulic lines. These lines should be firm and dry. Replace a line if there is the slightest trace of brake fluid or oil on the covering or if it shows signs of gumminess and softening.

Although they are less subject to damage or deterioration, the metal lines that connect the master cylinder with the flexible lines should also be checked carefully.



▲ Pen points to access hole in brake backing plate. When rubber plug is removed, you can adjust manual adjusting brakes, or manually back off self-adjusting brakes that have over-adjusted and prevent drum from coming off. In this case, however, both awl and adjusting spoon must be inserted in hole (awl to push away adjusting lever, spoon to turn star wheel).

➤ Check brake hydraulic hoses for leaks, cracks and other signs of weakness.



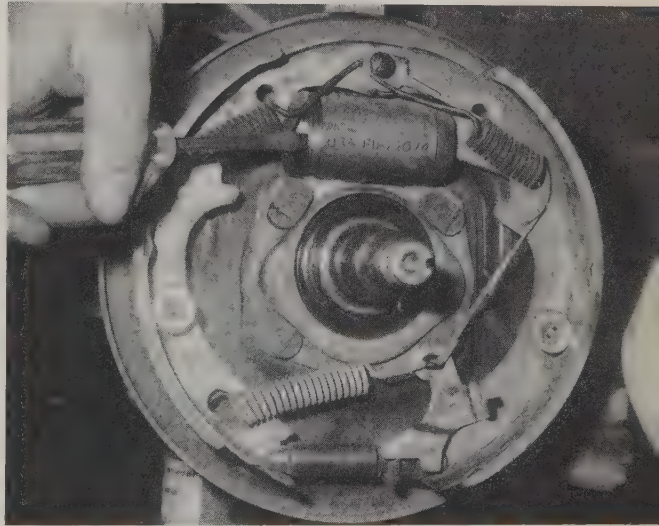


◀ When you check a master cylinder for leaks, begin by cleaning it off thoroughly first, so you do not confuse road splash and engine oil with brake fluid.

Check for leaking connections, dents, loose fastenings at the frame, and for signs of abrasion or wear on the guards where the line bends around the frame. While you are under the car, check the parking brake cables for wear and the inside of the wheels for bearing grease leaks. Such a leak can affect the operation of your brakes due to grease entering the brake drum and soaking the linings.

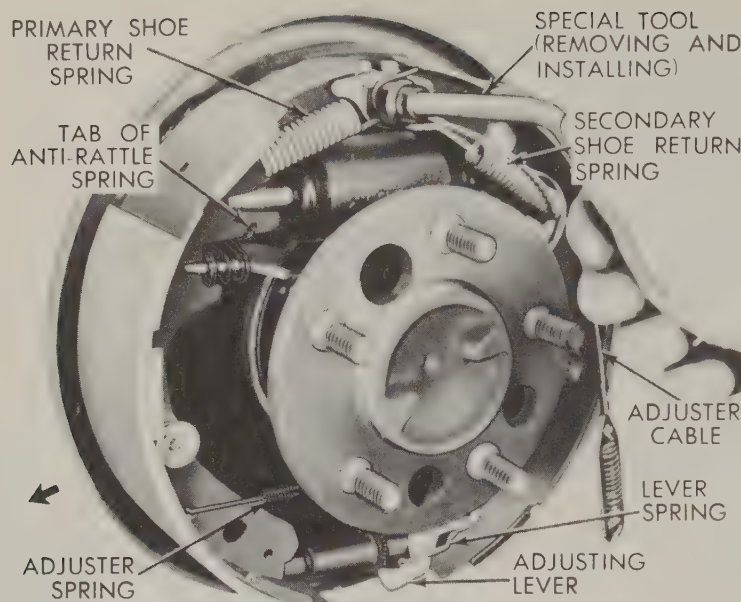
Now inspect the master cylinder closely for leakage. Leaks at the brake line connection can often be corrected by tightening, but if the fluid is coming from around the piston rod, the master cylinder is in need of overhauling and must be removed. To remove it, disconnect the brake line, remove the wires from the spotlight switch and unfasten the push rod from the pedal. Then remove the mounting bolts and lift out the cylinder for rebuilding as described later.

Continue your brake check by removing a front and a rear brake drum to inspect the linings and shoe mechanisms. Do not decide whether relining is necessary on the basis of a front or rear wheel alone. It is true that the front linings wear faster, but a poorly adjusted, dragging parking brake can put wear on the rear shoes in a hurry.



▲ Leaking wheel cylinder can be checked by pushing away dust cover at each side with a screwdriver and looking for signs of brake fluid seepage.

In the classified section of your phone book, locate an auto parts dealer who advertises pickup and delivery machine shop service. Go to see him to make certain he has all the parts you may need to complete the brake overhaul and get an estimate of their cost. Also, while you are there, you may have to borrow or rent a universal wheel puller to remove



◀ Disassembly of drum brake can begin with disconnection of self-adjusting cable on cars so equipped, and removal of brake shoe return springs. Taking off and refitting springs is easier with the special tool shown, but you can also use a screw-driver.

your rear brake drums. Occasionally, when accompanied by a parts order, there is no charge for the use of this tool.

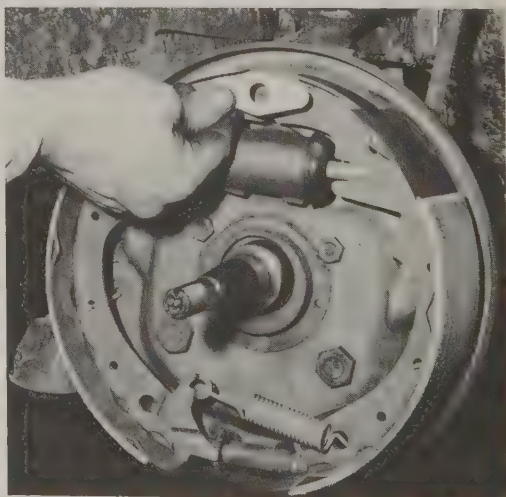
Now block up the car and place a piece of wood under the brake pedal to prevent it from accidentally being pushed while the drums are removed. Remove the hubcap and dust cap from a front wheel and then, without removing the wheel, pull the cotter pin and remove the nut from the spindle. Get a good grip on the two sides of the tire, wiggle it a bit, and pull straight back. The tire, wheel, brake drum and wheel bearing should slide off easily as a unit.

To remove a rear brake drum, you may need the universal wheel puller. After removing dust cap, cotter pin and castle nut, fasten the three arms of the wheel puller under three lug nuts of the wheel and then turn the screw until it is against the axle shaft. Rap on the striking anvil with a hammer until the drum comes free.

Lining inspection. As soon as the drum is removed, brush the dust off of all parts and make a close visual inspection of the

linings, brake drums and wheel cylinders. If the shoes are to be removed, label each one to show its location. Don't mark on the linings; when they are replaced, the marks will be lost. It may help you to remember the location of the springs and pins if you make a sketch of the assembly for a front and rear wheel.

If the linings are worn down to with-



▲ With return springs removed, anchor plate can be taken out.

Servicing Drum Brakes Yourself

in $\frac{1}{16}$ -inch of the rivets or shoe steel back, they must be replaced. For safety's sake, also change linings if they have become coated with brake fluid or grease.

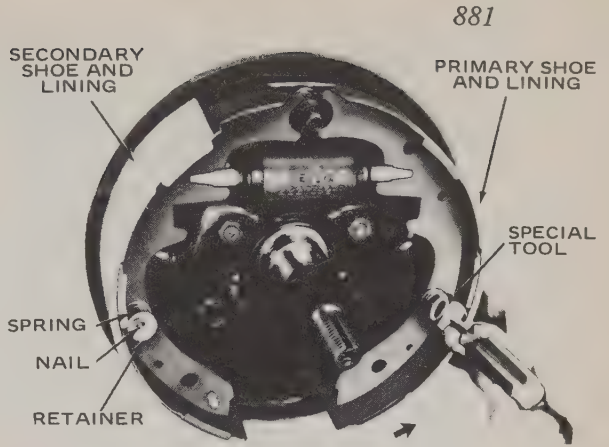
To remove the brake shoes, first unhook the retractor spring. This spring is most easily removed with a special pliers that can be purchased for about two dollars. You can use an ordinary pliers, but it takes a powerful grip and extra care not to let the spring slip.

Tie a cord around the wheel cylinder or use the special clamp to keep the pistons from popping out of the cylinder when the shoes are removed. Then, if the shoes are held to the back plate by a spring-loaded pin, compress the spring, turn it 90° and release it to free the brake shoes.

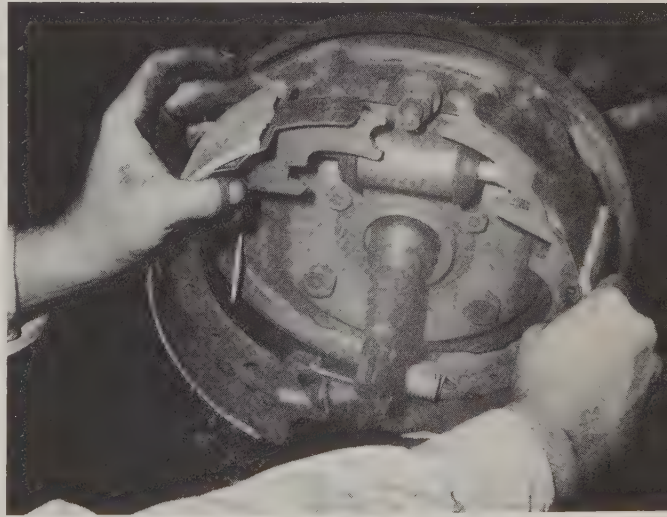
When disassembling the rear brakes, remove both shoes, the parking lever, the shoe adjusting screw and its lock spring as a unit. Then disconnect the parking brake lever from the shoes and just let it hang from the cable.

Drum inspection. If the linings have worn down to the rivets and the drum is scored deeply enough to have made lengthwise marks on the shoes, have the drum reground at a brake shop. Brake drums should be replaced if there are any signs of cracking, warping or heat discoloration. The number of times a drum can be reground depends on the amount of metal removed during grinding. Since .060-inch is the maximum amount that can be safely removed, drums can seldom be reground a second time.

Check to see if there is a sharp shoulder at the back edge of the braking surface in the drum. This means the drum has been reground at least once and that if it is deeply scored now it is likely the drum must be exchanged. In either case, wire the labeled brake shoes and their drum together so they can be sent to the



▲ Retainer spring assembly is shown being removed with special tool. Job also can be done with screwdriver. Just press down spring with screwdriver and twist the retaining nail with fingers to free the assembly.



▲ Shoes are pulled away from the anchor pin and lifted away from the backing plate.

brake shop as a unit and the shoes fitted to that drum or its replacement.

Now turn up the edge of each of the rubber boots on the wheel cylinders to see if fluid has been leaking by the piston. Also check along the back plate for signs of leaking. If there is the slightest amount of leakage, all of the cylinders probably need service.

If your car is in need of a complete brake overhaul order a rebuilding kit for each wheel cylinder and one for the master cylinder, along with a hone for the cylinder bores. Also ask to have the brake shoes relined and, if necessary, have the drums reground. With this, purchase a quart each of heavy-duty brake fluid and a brake line flushing compound. Even if all of these materials are necessary, you will only have spent between \$30 and \$50 as the total expense for your brake overhaul; a fraction of the cost of having it done.

Since the replacement parts for rebuilding the cylinders may differ slightly in appearance from the original, check to see that there are instructions for assembling them in each kit. Also see that

the brake shoes are still with the correct drums by checking the markings you made during disassembly.

Then remove the boot and brake shoe push rod from each wheel cylinder and gently press against one of the pistons until the opposite piston and its rubber cup are forced out of the other end of the cylinder. Remove the piston spring and push the remaining piston and cup out from the other side. If the brake system has two wheel cylinders, one end of each cylinder will be closed and the piston must be forced out by applying a light pressure on the brake pedal. On some models there is also an expander located between the end of the piston spring and the cup which should also be replaced.

WHAT'S THE MATTER WITH YOUR BRAKES?		
Condition	Possible Cause	Remedy
PULLING CAR TO ONE SIDE	1. Tires unevenly inflated or worn unevenly	1. Replace with matched tires on each side and inflate evenly
	2. Shoes need adjustment	2. Adjust brakes
	3. Back plate or wheel bearings loose	3. Tighten plate; replace and/or adjust bearings
	4. Grease or fluid soaked lining on one wheel, lining charred	4. Replace linings and repair grease or fluid leak
	5. Moisture or mud on shoes	5. Clean out brake assembly with water if muddy. Drive slowly and maintain light pressure on brakes until friction dries lining. Replace rubber plug in back plate if necessary
	6. Drum scored or out of round	6. Regrind or replace drums
	7. Dissimilar linings on one side of car	7. Replace with matched linings
	8. Weak or loose chassis spring	8. Tighten or replace worn part
	9. Worn king pins	9. Replace worn parts
ONE BRAKE DRAGGING	1. Shoe clearance insufficient	1. Readjust dragging brake
	2. Hydraulic line clogged or crimped	2. Flush system or replace line
	3. Loose wheel bearings	3. Tighten or replace bearings
	4. Weak or broken shoe return spring	4. Replace spring
	5. Shoe sticking on anchor pins	5. Lube anchor pins and other contact points
	6. Wheel cylinder pistons sticking	6. Hone cylinder and replace piston

WHAT'S THE MATTER WITH YOUR BRAKES?		
Condition	Possible Cause	Remedy
HARSH OR GRABBING	1. Linings are wet or damp 2. Back plate loose 3. Charred, grease soaked or improper linings 4. Drums scored	1. Drive car slowly while maintaining light pressure on brake pedal until friction dries linings 2. Tighten back plate screws 3. Replace linings 4. Regrind or replace drums
SQUEAKING	1. Loose wheel bearings 2. Metallic particles or dust imbedded in lining, worn lining 3. Bent back plate 4. Bent shoes	1. Replace and/or adjust bearings 2. Replace lining 3. Repair or replace back plate 4. Check installation and replace shoes
KNOCKING	1. Roughly finished or warped drum 2. Adjusting slot in shoe is not square	1. Replace or regrind drum 2. Repair or replace shoe
INADEQUATE RESERVE CLEARANCE AT BRAKE PEDAL	1. Low fluid level in master cylinder 2. Pedal and/or shoes need adjustment 3. Air or fluid vapor trapped in system 4. Fluid leak in system 5. Worn lining	1. Add fluid 2. Adjust pedal and shoes 3. Bleed system 4. Repair or replace defective lines or cylinders 5. Replace lining
BRAKES DRAG AFTER ADJUSTMENT	1. Vent in filler cap is clogged 2. Inadequate freeplay at pedal 3. Brake lines clogged or crimped 4. Rubber pistons swollen	1. Clean vent 2. Adjust master cylinder push rod or brake pedal eccentric bolt 3. Replace line and/or flush system 4. Check and replace brake fluid

Note that wheel cylinders can only be rebuilt if the cylinder bores are in good condition. Very light scratches and corrosion can be cleaned with crocus cloth. If there is any question in your mind, replace the wheel cylinder.

The practice of honing out wheel cylinders that are moderately scored is of questionable value. A replacement cylinder is little more expensive than one that is professionally honed and rebuilt by you. Your safety is worth the small extra expense.

If the cylinder bore looks bright and

free from scratches, wipe it thoroughly with a soft clean cloth dampened with brake line cleaner. Then insert one of the new pistons and check the clearance between the piston and the cylinder wall with a feeler gauge. This clearance must not be more than .004-inch. If it is over .004, which is very unlikely, you will have to replace the cylinder housings.

Master cylinder overhaul. Mount your master cylinder in a vise and clean the outside of it thoroughly before beginning disassembly. Position the cylinder so the push rod from the pedal is toward you

and you will see either a retaining wire or a metal collar held with a pair of capscrews. Remove this retainer first so you can take out the piston, piston cups, spring and valve from the cylinder. Lay these parts out in order for reference when assembling the new parts, but do not under any circumstances use them when reassembling the cylinder. The exact number and style of the parts will differ with each make and year of car.

Some Buick cars in the late 1950's had a unique master cylinder in which the piston did not fit against the cylinder walls. This cylinder is serviced by separating the cast housings and removing the retaining wire to expose the long, rod-like piston.

Check the bore and the valve seat at the end of the bore for rust or corrosion and clean, if necessary, with crocus cloth or a commercial rust remover. Follow the same procedure for the master cylinder as was used on the wheel cylinders if the bore is pitted or scratched. Then reassemble the cylinder with the new parts from the kit, following the enclosed instructions.

Install the master cylinder in the car, connecting the lines and the stoplight switch and checking to be sure that the push rod is lined up to work freely before tightening the mounting bolts. Adjust the free play as described. If it is necessary to replace any of the hydraulic lines, do so now. No sealer of any kind is necessary or desirable here as the brass fittings will make a very tight seal under moderate pressure.

Brake line flushing. Pack each wheel cylinder with a clean cloth and fill the master cylinder with the brake line cleaning fluid. Then remove the cloth from one cylinder at a time and flush the brake line by pumping the fluid through it with the brake pedal. Refill the reservoir and continue this until the distinct color

Servicing Drum Brakes Yourself

of the cleaner can be seen when it is forced out at the wheel cylinders.

Pump the cylinder until the system is empty and then reassemble the wheel cylinders according to the instructions in the kits. Lubricate all the new parts with brake fluid before assembly and insert them from the end of the cylinder in which they will operate. Do not try to push the cups through from one end as the rubber parts may snag on the bleeder or inlet hole and be damaged. If trapped air forces one piston out when you insert the other, open the bleeder valve to relieve the pressure.

If any of the parts become dirty while they are being assembled, rinse them in the brake line cleaning fluid, allow them to dry and then dip them into fresh brake fluid again. Do not use the brake fluid that has been used for lubricating these parts or the hone to refill the master cylinder as it will contain grit and air bubbles. Also, do not allow any oil or grease to come into contact with the cylinder assembly as it will deteriorate the rubber parts. When the wheel cylinders have been completely assembled, snap on the boots and push rods and secure them temporarily by tying or using clamps.

Brake shoe assembly. Before installing the brake shoe assembly, coat the threads and contact surfaces of the adjusting screw with a high temperature fiber or silicone grease. Also coat the raised shoe guides on the back plate with this grease.

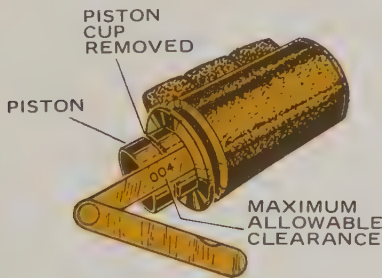
Then mount each brake shoe on the anchor pin and set it in the cylinder push rod slots. On Bendix type brakes, screw the adjusting screw all the way in, that is, make it as short as possible and fit it between the lower ends of the shoes. Assemble the hold-down pins by placing the plates over the spring and pin, compressing the spring and turning the assembly 90°. On other type brakes, turn the eccentric cam adjust-

Servicing Drum Brakes Yourself

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▲ Star wheel should be inspected carefully. It must thread in and out easily, or threads should be immersed in solvent to remove rust and then be coated with silicone lubricant. Teeth of star wheel should not be damaged. This is particularly important on self-adjusting brakes, which have 24 small teeth per star wheel, compared with 12 larger ones for the manual adjusting brakes.

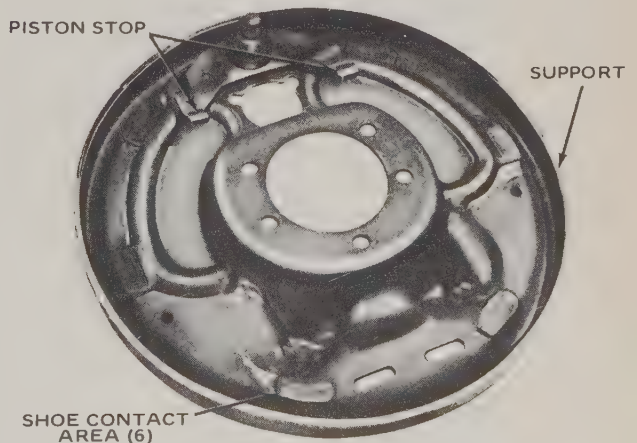


▲ To check wheel cylinder bore, take piston with sealing cup removed and insert in bore. Try to insert an .005-inch feeler gauge. If it can fit in, the bore is too large and the wheel cylinder should be replaced. A clearance of .004-inch between piston and bore, measured with a feeler gauge, is maximum permitted. With everything off the backing plate, it should be cleaned and the raised shoe contact areas (six on the backing plate illustrated) should be coated lightly with silicone grease. ➤

ment so its low point will be against the shoe. Finally, secure the entire assembly with the retracting springs and attach the self-adjusting mechanism.



▲ Brake drum surface that comes in contact with brake shoes should be smooth. If you can hang a fingernail on a score, drum must be resurfaced or replaced. Minor scratches can be removed with crocus cloth.



Be sure to replace the parking brake lever on the rear wheel by connecting it to the shoe with the pin and then crimping the horseshoe washer over the pin end. Repack the front wheels and replace the grease seals in the hubs if necessary. Then fit the drum over the shoe assembly. On brake assemblies where both ends of the shoes fit in slots, it may be necessary to center the shoes somewhat to install the drum. Do this by moving each shoe in the right direction by hitting it with a soft-mallet or the heel of your hand.

Be sure to replace the key and lock washer on the rear drum and then draw all of the hubs up tight. Back off the front axle nut to the next cotter pin slot, insert a new pin and replace the dust cover. If the rear brake drum is fastened to the hub with sheet metal nuts, use new ones when reassembling.

Bleeding. Before replacing the wheels, bleed the entire brake system of air. The principle of operation in a hydraulic system is built around the fact that fluids are not compressible. The presence of even a small quantity of air, which is easily compressible, will seriously affect its efficiency. Your car is equipped with bleeder valves which allow this air to escape when they are opened, but it is up to you to see that air is not drawn back into the system.

You can bleed your brakes by having a helper operate the brake pedal while you control the flow of fluid through the bleeder valves. First close all the valves and then fill the master cylinder. Replace the cap and have your helper pump the brake pedal a few times. Then check the level of the fluid again and add more if necessary. Now have him hold a steady pressure on the pedal while you open the bleeder valve with a small wrench.

Check the color of the fluid that escapes to be sure the cleaner is completely expelled. The fluid will squirt through

the valve with a sputtering sound until there is no more air in the line. This may take two or three pumps of the pedal. Your helper should let you know each time the pedal is just about to the floorboard so you can close the valve while there is still pressure in the line. Check the master cylinder reservoir after each wheel is bled and keep it filled to the proper level.

Bleeding attachments are available which will allow you to do this job by yourself. These will usually have three fittings to adapt to all cars and will have a ball-check valve to prevent air from being drawn into the system when the pedal is released.

When all points have been bled, the pedal action should be firm and should maintain the correct reserve clearance under continued pressure. On the second pump of the pedal the reserve should be no greater than on the first pump. If this is not the case, repeat the bleeding operation. If the second bleeding still does not provide the proper pedal action, check for leaks that may have been overlooked during assembly.

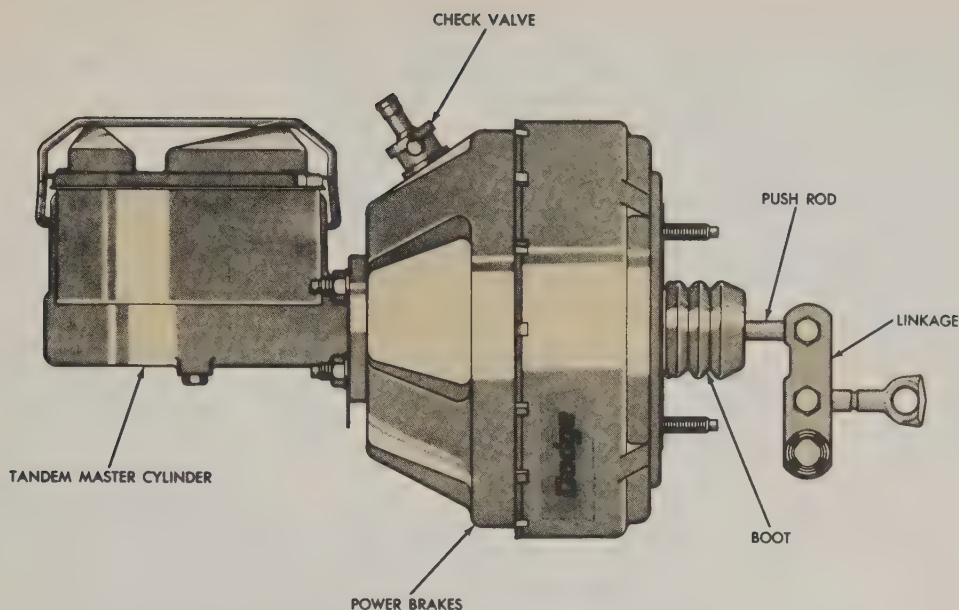
The next step is to adjust the brakes. On the typical late-model car, all that is necessary is to drive in reverse at low speed and apply the brakes, and they will adjust automatically.

Brake shoes, like most equipment on your car, should be broken in carefully for long, trouble-free use. Allow the shoes about 100 miles of moderate use before attempting mountainous roads or frequent fast stops. After 100 miles make another adjustment as before and recheck the lines for leaks.

Then, with these service adjustments and inspections at 5,000-mile intervals, the brake system overhaul as described will provide safe, carefree service for 30,000 miles.

P.W.

See also: DISC BRAKES.



▲ Typical power brake arrangement on car with dual master cylinder. Adjustment of pedal height is on the link (extreme right), which is threaded.

Trouble-shooting Power Brakes

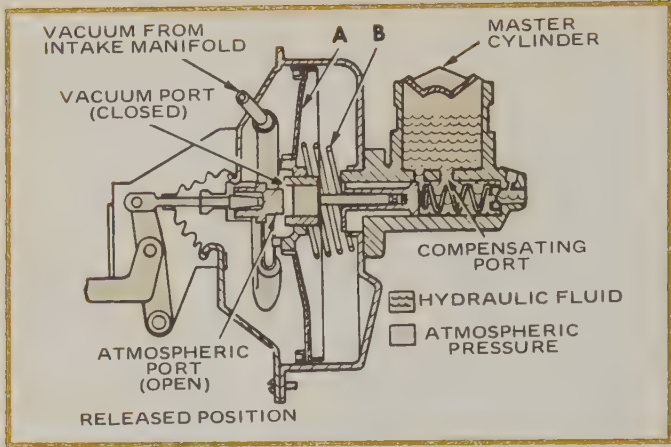
You can make simple tests on your brakes to avoid costly replacement of linings and excessive fuel consumption

SO-CALLED POWER BRAKES are not really power *brakes*. In most types, power assist from engine vacuum helps you push down the brake pedal of an otherwise ordinary hydraulic brake system. All makes of power brakes, or more exactly power boosters, used on American cars, are similar and fairly simple in operation and maintenance.

Basically, the power booster is a vacuum operated cylinder added between the brake pedal and the hydraulic master cylinder. When you touch the brake

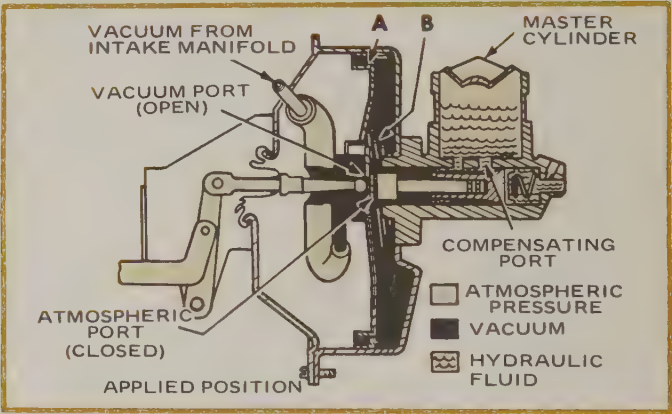
pedal lightly, vacuum sucks a piston forward to push hydraulic fluid from the master cylinder into the brake lines and out to each wheel cylinder. Without power assist, your foot pedal linkage pushes directly on the piston in the master cylinder. (This is what gives non-power brakes a better feel and controllability than power brakes even though it takes more leg power to operate them.)

Most vacuum brake booster units have three major parts: vacuum cylinder, vacuum piston with built-in control valve,



◀ Vacuum power cylinder in released position with air pressure equal on both sides of power piston (A), located by return spring (B).

➤ Power cylinder with brakes fully applied. Piston (A) has been sucked forward by engine vacuum, through vacuum valve, compressing spring (B) and forcing piston in brake master cylinder to apply the brakes.



and end plate with bracket and lever assembly. Vacuum to power the unit comes from a tube attached to the intake manifold of the engine.

When your foot is off the brake pedal, the vacuum unit is in the released position. The vacuum port to the engine remains closed, but the atmospheric port is open. Air can pass freely from one side of the piston to the other. With equal pressure on both sides, the return spring holds the piston in the off position. Another port, the compensating port, between the vacuum cylinder and the hydraulic master cylinder is also open. This lets hydraulic fluid from the brake lines return to the master cylinder.

When you touch the brake pedal, the

atmospheric port closes and the vacuum port opens. Vacuum from the intake manifold then sucks the piston forward against the pressure of the return spring. This motion pushes the operating rod in the hydraulic master cylinder to apply the brakes.

Should the power booster fail, then the operating rod for the power system would move forward to push directly on the operating rod for the master cylinder hydraulic piston. Thus, when you stepped on the brake pedal, you would notice slightly longer pedal travel and increased braking effort, but you could still stop the car.

Trouble-shooting power brakes calls for some simple tests you can make yourself. You can repair leaks in connections

Trouble-shooting Power Brakes

➤ Vacuum hose to power brake unit is shown disconnected and with engine running you should feel vacuum at end of hose.



◀ If vacuum valve is defective, it can simply be pulled out of the rubber grommet in which it sits in the power brake unit.

and hoses, or replace the whole vacuum unit with a rebuilt; but very possibly, repairs to this unit may require special tools and skills as well.

Start by testing booster operation. Shut off the engine and pump the brake pedal several times to exhaust all vacuum in the system. Older model power brake systems often incorporate a vacuum reservoir tank, so these may take a few more pumps on the pedal to clear them of vacuum.

Now step on the brake pedal and hold it down firmly while you restart the engine. If the vacuum system is working right, the brake pedal will move forward slightly when the engine starts. If there is no movement and the pedal feels hard, the vacuum unit is not working.

The fault may lie in the unit, or it may not be getting any vacuum. Check by removing the vacuum hose from the power cylinder. Hold your thumb over the open end of the hose. You should be able to feel the suction.

No vacuum at the hose means there is a leak in the system, or the engine is not in good shape. Check the hose for kinks, collapsed areas, or tears. Replace the hose if defective.

If the hose is working properly and you still get no suction, check for vacuum at the intake manifold. A vacuum gauge should show 17 to 21 inches with the engine idling. If it does not, check first for manifold leaks. A quick way is to idle the engine after putting oil on the joints at

carburetor flange to intake manifold and intake manifold to cylinder block. If there is a leak, vacuum will suck in the oil to seal it temporarily. With proper vacuum, the engine will speed up. Fix the leaky joint by tightening the attachment bolts, or if this does not work, by replacing the gasket.

If you find no leaks, lack of manifold vacuum points to the need for an engine tune-up or possibly even an overhaul.

If there is vacuum at the hose, but the booster unit does not work, the vacuum booster itself is at fault. Before removing the unit from the car, test the vacuum check valve, a common cause of trouble.

The vacuum check valve is a one-way affair which lets air be sucked out of the vacuum booster into the intake manifold but does not let the vacuum out of the unit when the engine is shut off. To remove it from the cylinder, disconnect the vacuum hose and simply unscrew the valve. In most systems you can do this without removing the vacuum cylinder from the car.

Check the valve by blowing through it; first one way and then the other. No air should come out the end to which the vacuum hose is attached, but you should be able to blow through other end. If the valve is faulty, replace it.

If the valve is in good condition but the unit still does not operate, you must remove unit from the car. Further disassembly and inspection should be performed by a serviceman experienced in vacuum unit repair who has the proper tools for the job. He can repair the unit for you, or you can exchange it for a new or rebuilt unit.

You can, however, test your vacuum unit to see if it is causing the brakes to drag. This can wear out one set of linings after another in addition to cutting deeply into your fuel mileage.

First make sure shoes are properly adjusted and that wheels turn freely. Raise

the front end of the car and start both front wheels spinning. Immediately start the engine and let it idle. Keep your foot off the brake pedal. Each front wheel should coast to a stop and still turn freely. If one or both stops more quickly than it should, or if you can feel a noticeable drag, there is trouble in the vacuum unit. You may find it necessary to have it repaired, or even replaced.

All power booster units have a filter to clean the air drawn into the system. On some boosters this filter is external and can be removed for cleaning. Check the workshop manual for your car to see if it has this type of filter and how often it should be serviced. Many makes have an internal filter which only needs servicing when the booster cylinder is removed from the car.

To clean either type of filter, wash it in alcohol or some other non-oil base solvent. Gasoline or similar solvents should be avoided because they can damage rubber parts in the braking system.

One last check completes the work you can do on your power brake system. Make sure no brake fluid is being sucked through the vacuum line into the intake manifold. To do this, remove the vacuum hose from the intake manifold and run a screwdriver or pencil around the inside of the open end. If it comes out wet with brake fluid, there is a serious leak past the vacuum cylinder piston. The whole unit will have to be rebuilt or replaced to cure this leakage. If it continues, the engine will idle roughly, perform poorly, and hydraulic fluid can form gums which cause sticking valves and may create a variety of other problems.

These simple checks will enable you to tell when your power brake booster is working properly. When it is not, they will help you pinpoint the trouble, and in many cases you can cure it yourself.

See also: DISC BRAKES.

How to Camouflage Your Duck Boat

Attach marsh grass to lath frames. These can be carried on deck to the site, then erected to convert your boat into a floating blind

TEMPORARY CAMOUFLAGE is a cheap and easy way of converting your summertime skiff into a floating duck blind. Using a lath framework laced with swamp grass, as shown in the accompanying photos, you achieve the conversion with a minimum of fuss. The camouflage matting may be stored in a garage after the season, then used year after year.

The average boat is decorated in pale blues, whites and varied brilliant hues that are eye-appealing during summertime. Once hunting season rolls around, the wary pintail, black, broadbill and canvasback flee from the identical hull that is so attractive during bluebird weather.

Waterfowl will flare from flashes of light reflected from your gun barrel, thermos jug, or even from a hunter's exposed face. A boat's mooring cleats or other brightwork are frightening sights to ducks going over high, making up their minds whether to set their wings and drop into the stool. If you're going to extend the pleasures of boating into the gunning season and get more pleasure out of your nautical gear, a few frames of lath over-

laid by blankets of swamp grass will increase your game bag without denting your bankroll.

Make half a dozen screens of 1x2-inch lath, using scrap materials wherever they are available. If you want the rig to last over several seasons, paint the wood a dull grey or some other camouflage color. Match this hue on any fastenings you use, paying particular attention that no bright metal shows.

Lay swamp grass over the frames in "sandwich" fashion between overlapping strips of the lath. Nail them fast.

Obviously, there are dozens of ways to attach this covering to your hull. You can ride to the hunting ground with the camouflage stacked on deck and set it up upon arrival. One easy system is to screw brass screen hooks into the top longitudinal stringers of your hull, inside the boat's cockpit. This keeps them out of sight. In use, simply attach the frames with a piece of 1/4-inch line.

In mooring this floating blind for maximum comfort, use fore and aft anchors with the hull broadside to the wind. The decoys should be placed to the leeward. If the use of two anchors is inconvenient, use a single off the bow, bridling the boat by leading a rope from the bow anchor rope aft to a stern cleat.

You should lay so the gunners shoot over the gunwale or beam, broadside to the wind. During particularly sloppy weather conditions, temper this by quartering

duplicating jig: see lathe
dutch colonial seats: see early american
dutch-style decorating: see decorations
dwarf trees: see bonsai
dye, aniline: see finishing, wood



▲ Your summer boat can be doubly useful as a floating duck blind with marsh grass woven into lath frames. When hunting, tilt up outboard and lock it.



▲ On the way to a shooting spot, carry the camouflage stacked on deck.



▲ Construct the frames with 1 x 2 inch laths nailed together.



How to Camouflage Your Duck Boat
into the chop. Always leave open water between your floating blind and the decoys.

Attach wooden blocks or floats to each anchor line so you can cast off easily to retrieve downed birds, then resume your position quickly. Make fast a piece of brown canvas at the bow, rolling it back over the entire exposed deck while in shooting position.

To comply with all federal and local regulations, tilt your outboard up in a locked position when at anchor. Disconnect remote tanks. Cover the engine with a standard motor cover, another section of camouflage canvas, or an old gunny-sack.

There is nothing permanent about any part of this rig. After the waterfowl season, store the lath frames in anticipation of further use. No structural or unsightly changes have been made to the family boat other than the fasteners attached underneath the coaming, and they're handy for use in lashing fenders or bumpers alongside any time of the year.

See also: BOATING; DECOYS; HUNTING; SHOTGUN; SKIFF, HUNTING AND FISHING.



▲ Without special frames, put ashore and camouflage your boat with available vegetation.

◀ Weave marsh grass into the frames.

Traditional Dry Sink with a Modern Elegance

**This versatile dry sink
can be built from pine
inexpensively and will add
Colonial beauty to your home**



EARLY AMERICAN FURNITURE has retained its popularity from Colonial days right up to the present. The dry sink shown here is a typical piece of the furniture used by the colonists. It was found in kitchens that lacked plumbing connections and was used primarily for washing dishes. Due to its recessed lined well, it is extremely serviceable and can be used as a bar, a buffet-server, a plant stand, or a simple storage cabinet.

A ready-made dry sink will retail for about four times what you would spend to build it yourself out of common pine. (The price will vary depending on lumber prices in your area and the type of wood you use for construction.) We recommend pine as is is easy to work with and the end grain poses no problem. It sands very smooth and takes paint or lacquer beautifully. Of course, it can also be left natural or stained. There are many ways to finish the piece. Another excellent possibility is to antique it. Whatever your choice, you can bet that

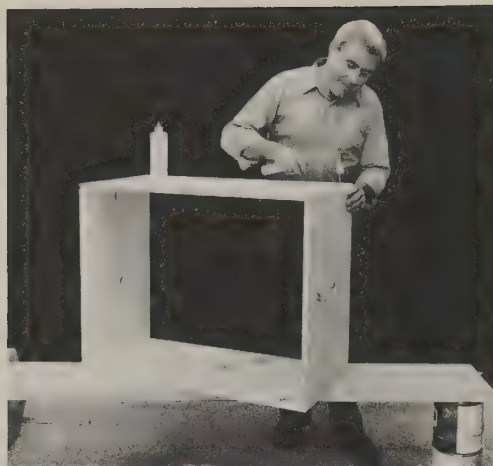
you'll have a great conversation piece, and an extremely useful one, when you're done with this one.

If you plan to paint the cabinet, you should choose lumber with a minimum of knots. To be sure of this, do not phone in your order, but go down to the lumber yard and personally pick out the best pieces available. You will undoubtedly end up with a few pieces with glaring knots, but you can place these where they won't show up, preferably the top or bottom panels. The top panel will be covered with plastic laminate and the bottom will be concealed by the doors.

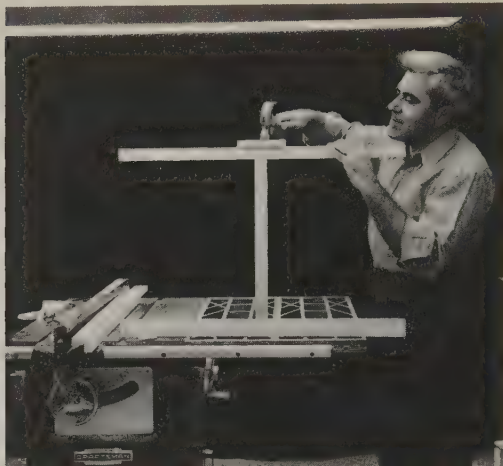
To eliminate the need for gluing boards, use 18-inch stock. These are glued up by the mill and the pieces are generally flat. Common pine is available in widths up to 24 inches.

Start the construction by building the main case which is really a large box. Cut the pieces to size, then rabbet the rear edges to take the 1/4-inch panel. Assem-

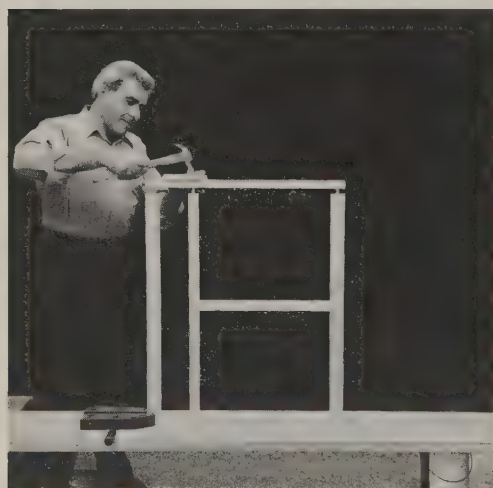
ecological kitchen: see kitchens
edge moldings: see moldings
edge-to-edge doweling: see dowels
edgings: see stonework
efflorescence: see masonry



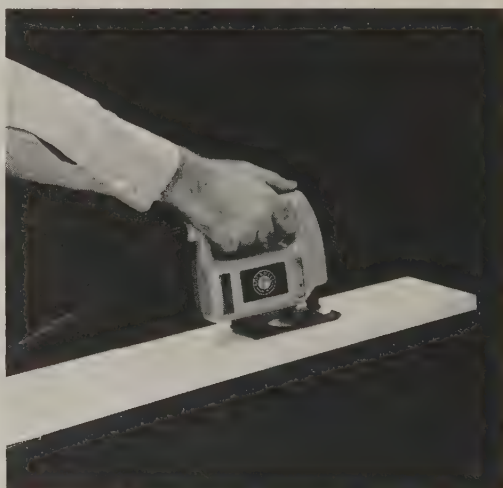
▲ Cabinet case is cut from 18-inch wide pine. Assemble with glue and finishing nails.



▲ Front frame must be accurate. Dowel construction is used here for added strength.



▲ Assembled front frame. Close all sections using hammer, block of scrap wood.

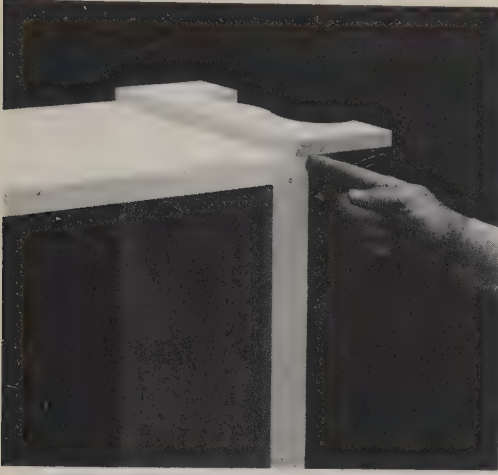


▲ Saber saw is ideal for cutting various scallops. Use a smooth cutting blade.

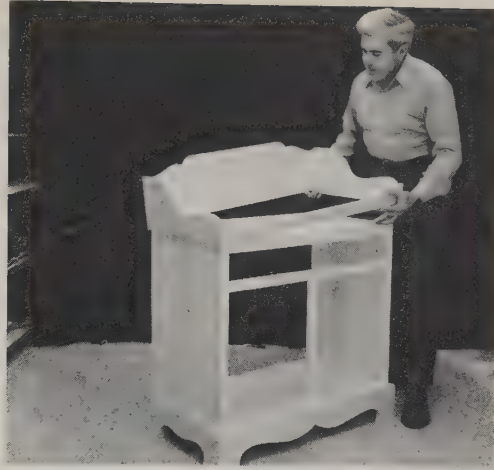
ble the parts with glue and nails. Butt joints are used throughout. If you can temporarily install the rear panel, you can use this to square the case.

The front frame is of doweled construction. The dowels assure that the frame will not separate and they add greatly to the strength of the cabinet. Follow the sequence shown to prevent difficulty in assembly. Glue the center section first

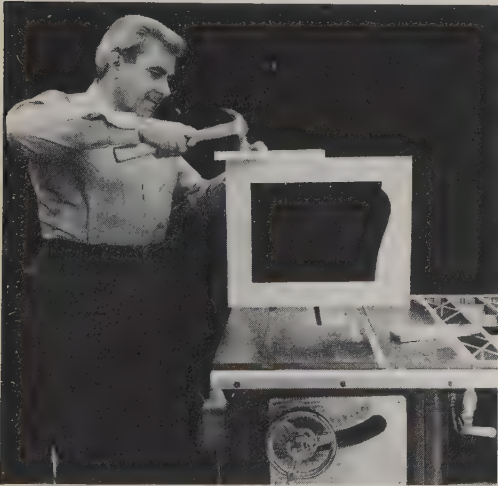
(shaped like the letter "H") then follow with the side pieces. Use spiral dowels or, if not available, use regular dowels but crimp the surface with a pair of pliers to form grooves. Use a hammer and block of scrap wood to drive the sections home. If clamps are available, use them. Otherwise use the rope and turnbuckle system (see illustration) to tighten up on the joints.

Traditional Dry Sink with a Modern Elegance

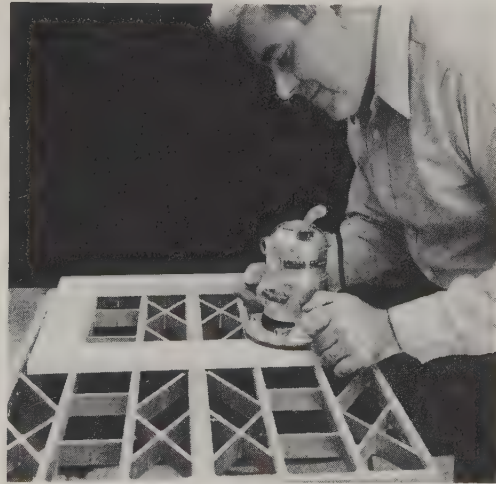
▲ Base pieces are added to sides. Allow sufficient clearance for the casters.



▲ Assembled top is fastened to cabinet. First measure, then cut plastic laminate to size.



▲ Doors of dry sink are of dowelled construction. Shaped top is cut before assembly.



▲ The doors are routed with small beading cutter. Back is rabbeted for $\frac{1}{4}$ -inch panel.

The base is installed next. Use a saber saw or jig saw to cut the scallops, then round off the edge of the scallop with a router. Note that the sides and front base pieces are placed on the outside of the case while the rear piece is positioned flush with the back of the cabinet.

The corner bracket casters are a good idea, though not essential. They reinforce the corners and automatically position

themselves. No measuring is necessary. Just place them in the corner, drive in the screws, and the casters will protrude just the right amount. Mounted on casters, the dry sink will be easy to move about the room whenever necessary.

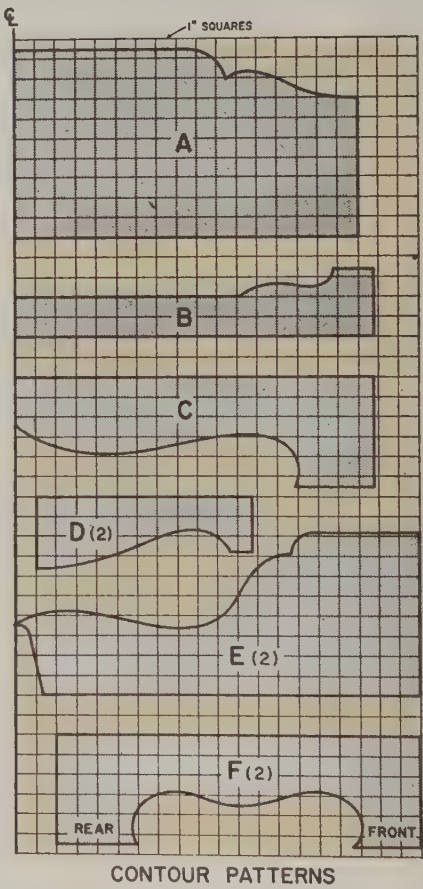
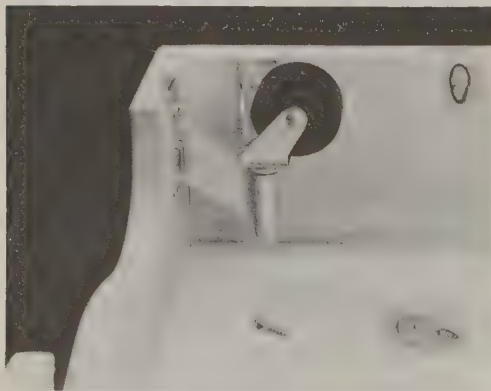
The top section is assembled as a unit and then installed onto the cabinet using 2-inch finishing nails. Before assembling the top pieces, round off all top edges with

Traditional Dry Sink with a Modern Elegance

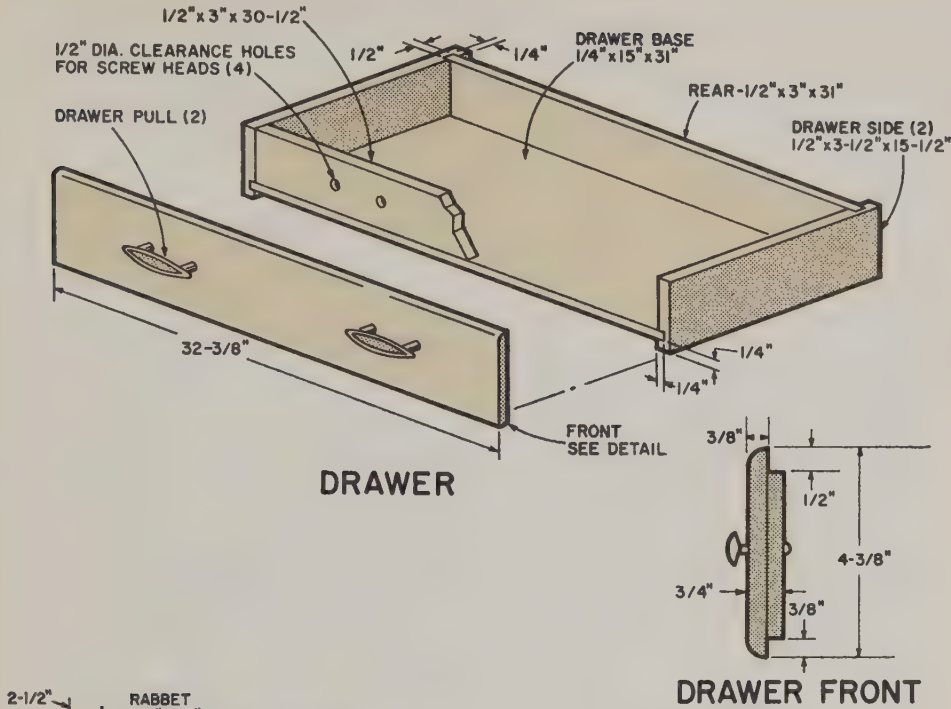
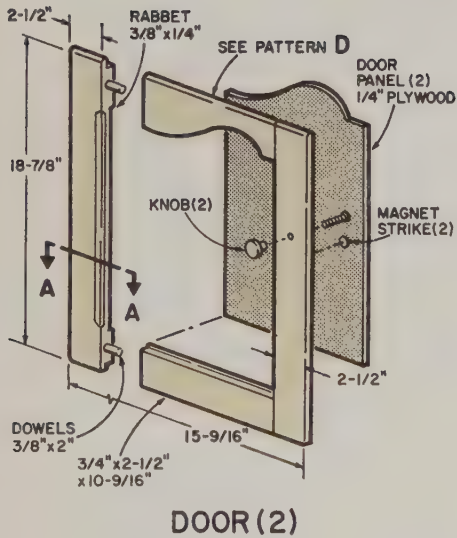
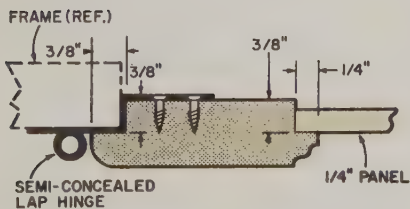
◀ Magnets are mounted in notched block which screws to the center divider.



▲ Completed cabinet with doors and drawer removed. Scrap 1/4-inch panel was used for rear.



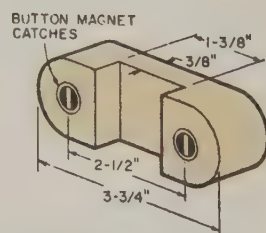
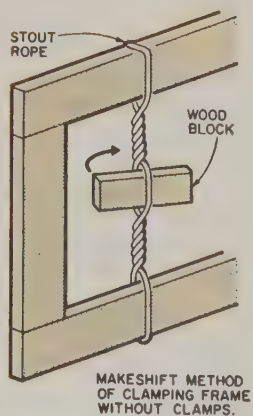
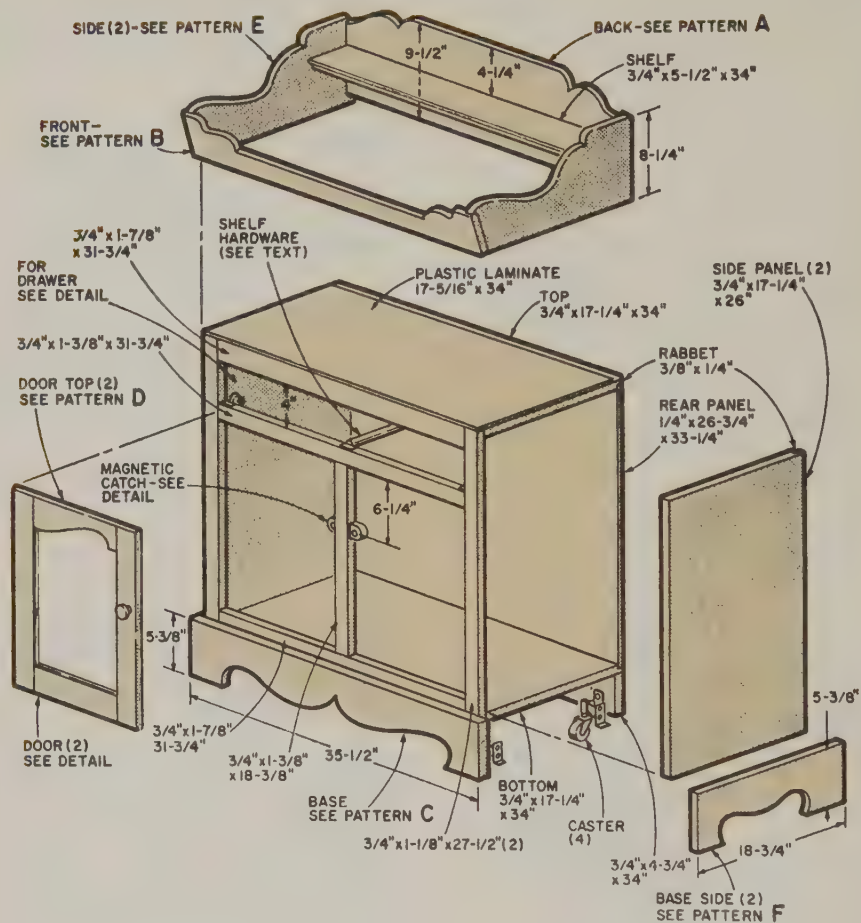
◀ Self-locating casters make unit mobile and give added strength to the corners.

Traditional Dry Sink with a Modern Elegance**DRAWER FRONT****DOOR (2)**

the router. Be sure to stop short of the ends at the rear side of the front piece where it joins the sides.

The drawer is of simple construction. The front is 3/4-inch pine; the sides and rear are of 1/2-inch pine. The bottom is 1/4-inch plywood. Follow drawing details for construction. The center bottom drawer slide makes for quick and easy installation. These are available at hardware shops and lumber yards everywhere.

The recessed panel doors are easy to make. All pieces are cut to size, then assembled with dowels. The scroll at the top of the doors is cut and sanded before assembly. The inside edge of the door (face side) is shaped with a router fitted with a small beading bit. The back side is done next with a square rabbeting bit to take the 1/4-inch panel. The depth of



MAGNETIC CATCH

MATERIALS LIST

Quantity	Size and Description	Purpose
1	$\frac{3}{4}$ " 5 $\frac{3}{8}$ "x35 $\frac{1}{2}$ " common pine	base front
1	$\frac{3}{4}$ " 4 $\frac{3}{4}$ "x34" common pine	base rear
2	$\frac{3}{4}$ " 5 $\frac{3}{8}$ "x18" common pine	base sides
2	$\frac{3}{4}$ " 17 $\frac{1}{4}$ "x34" common pine	case bottom and top
2	$\frac{3}{4}$ " 17 $\frac{1}{4}$ "x26" common pine	case sides
2	$\frac{3}{4}$ " 17 $\frac{1}{8}$ "x31 $\frac{3}{4}$ " common pine	frame upper and lower
1	$\frac{3}{4}$ " 1 $\frac{3}{8}$ "x31 $\frac{3}{4}$ " common pine	frame center
2	$\frac{3}{4}$ " 1 $\frac{1}{8}$ "x27 $\frac{1}{2}$ " common pine	frame sides
1	$\frac{3}{4}$ " 1 $\frac{3}{8}$ "x18 $\frac{3}{4}$ " common pine	frame center
1	$\frac{3}{4}$ " 5 $\frac{1}{4}$ "x34" common pine	top front
2	$\frac{3}{4}$ " 8 $\frac{1}{4}$ "x19 $\frac{1}{2}$ " common pine	top sides
1	$\frac{3}{4}$ " 9 $\frac{1}{2}$ "x34" common pine	top rear
1	$\frac{3}{4}$ " 5 $\frac{1}{2}$ "x34" common pine	shelf
4	$\frac{3}{4}$ " 2 $\frac{1}{2}$ "x18 $\frac{7}{8}$ " common pine	door stiles
2	$\frac{3}{4}$ " 3 $\frac{1}{2}$ "x10 $\frac{5}{8}$ " common pine	upper door rail
2	$\frac{3}{4}$ " 2 $\frac{1}{2}$ "x10 $\frac{5}{8}$ " common pine	lower door rail
1	$\frac{3}{4}$ " 4 $\frac{1}{2}$ "x32 $\frac{1}{2}$ " common pine	drawer front
1	$\frac{3}{4}$ " 1 $\frac{3}{8}$ "x3 $\frac{3}{4}$ " common pine	bottom magnet support
1	$\frac{1}{2}$ " 3 $\frac{5}{8}$ "x30 $\frac{1}{2}$ " common pine	drawer sub-front
2	$\frac{1}{2}$ " 3 $\frac{5}{8}$ "x15 $\frac{1}{2}$ " common pine	drawer sides
1	$\frac{1}{2}$ " 3"x30 $\frac{1}{2}$ " common pine	drawer rear
2	$\frac{1}{4}$ " 11 $\frac{1}{8}$ "x15" plywood	door panel
1	$\frac{1}{4}$ " 15"x31" plywood	drawer bottom
1	$\frac{1}{4}$ " 26 $\frac{3}{4}$ "x33 $\frac{1}{4}$ " plywood	rear panel

NOTE: Also need 2" finishing nails, white glue, button catches, drawer slide hardware, door pulls, drawer pulls, decals, casters, brackets, $\frac{3}{8}$ " dowels, plastic laminate and lap hinge.

the rabbet should be $\frac{3}{8}$ -inch to allow the panel to set below the surface about $\frac{1}{8}$ -inch.

To operate efficiently, the magnetic catches should be placed as near as possible to the door pull. The button magnetic catches shown are ideal as they can be mounted on a small block of wood which fastens to the center divider.

The plastic laminated top is recommended as it will take plenty of wear and cleans easily. If you plan to spray the

cabinet, mask the top surface of the laminate and install in the usual manner. If you are painting, paint the cabinet first, then install the laminate.

The colorful decals (fruits, flowers, birds) add to the appearance of the finished piece. The corner piece at the upper part of the door was made by cutting several of the ready-made decals apart and arranging them as shown.

J.C.

See also: DOWELS; FURNITURE, INDOOR; WOODWORKING.

Building a Colonial Hutch

You will save plenty by constructing this elegant piece of furniture yourself



THIS IS A FAIR-SIZED hutch dimensioned so that it can be constructed by using a single panel of 4 x 8-foot lumber core plywood for the main assembly. Pleasantly proportioned, the basic colonial design has been cleverly reworked to permit the piece to blend with a wide range of decor, enabling you to use it in the dining area, living room, or den.

The upper section features two good-sized shelves and a wide single drawer. This drawer front is made to appear as a double, simply for purpose of design, by cutting a partial saw kerf down the center and adding two drawer pulls. The delightful deceit is again repeated on the lower section. A horizontal saw kerf across both door panels and a pair of pulls relieves the otherwise "heavy" look of the lower cabinet, while ample storage space is provided behind the doors. If an actual set of drawers is your preference you can, of course, easily make the substitution.

Two professional tricks are utilized in the construction. The cabinet door trim appears to be carved right out of the panel but it is actually created by adding on ready-made straight and curved molding available as a stock item at most lumber supply dealers. Molded accent edges are shaped separately, cut into strips and also added.

The project illustrated was made of birch lumber core plywood, with solid birch for trim and base. Many fine hardwoods are available in lumber core form so the choice is yours.

Construction begins with layout. This first step is one which should be carried out with care because one wrong cut could prove quite costly. The reason is that lumber core is quite generally sold only as an entire 4 x 8-foot panel so you can't go back to buy an additional small piece should the need arise. Thus, it is advisable to carefully measure and mark off the

Building a Colonial Hutch

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various pieces *right on the panel*. Use a hard-leaded pencil and mark lightly. Be sure to make allowance for the thickness of the saw kerf at all cuts.

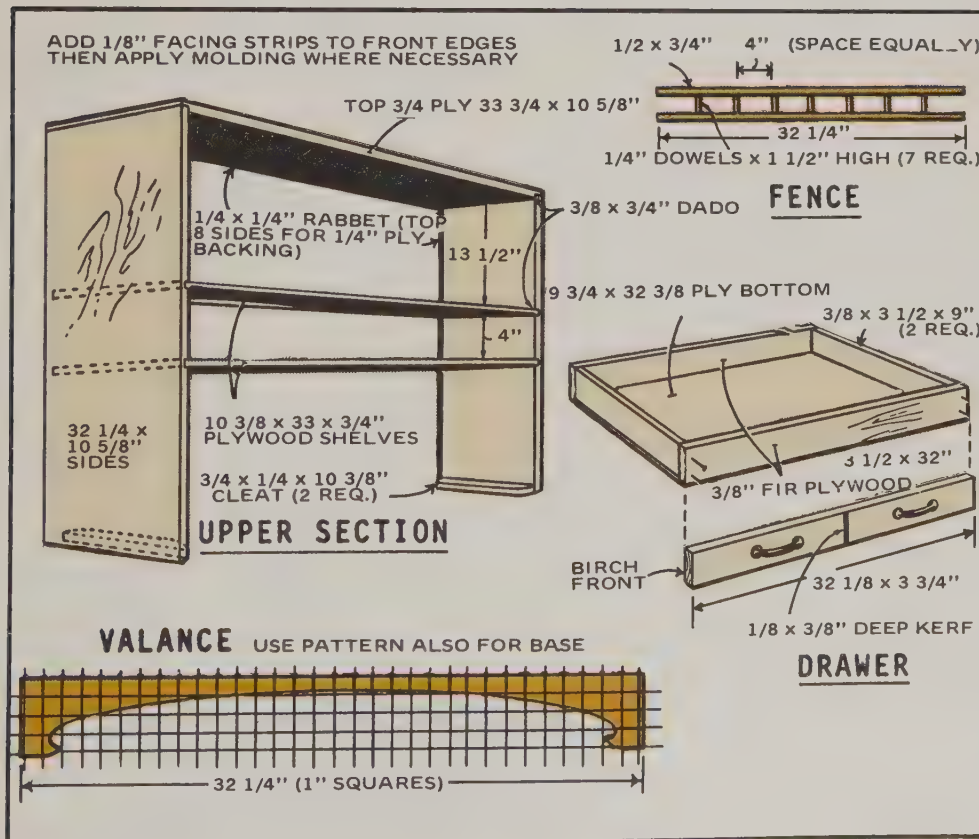
The radial arm saw is, by far, the most useful power tool for such construction but a table or portable circular saw can also be used. If yours is a small shop and the handling of a full 4 x 8-foot panel presents a problem, allow for several rough cuts in your layout (there will be sufficient waste for this purpose). Use a saber or even a hand saw to cut the panel into four bite-pieces which will handle easily.

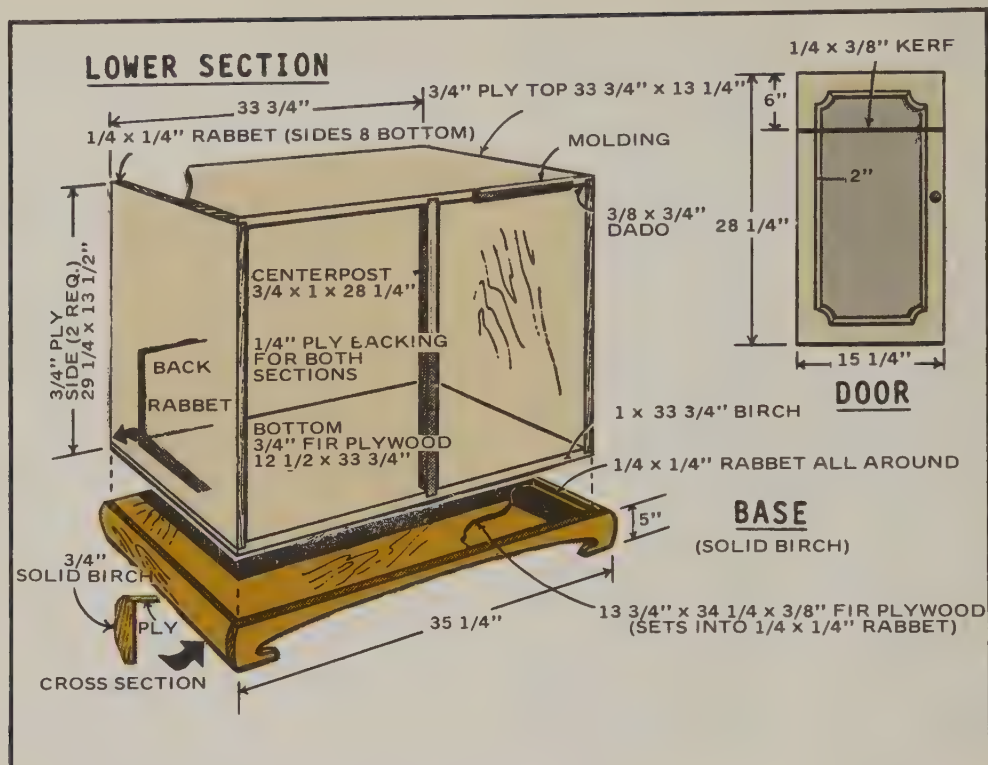
Use a planer or plywood blade on your saw to obtain clean, smooth cuts which will not require finish sanding. Cut all the main pieces and follow up by marking them for dado and rabbet cuts. Use of a

dado cutter simplifies the operation but a regular saw blade can also do the job if necessary. In the latter case, make twin cuts $\frac{3}{4}$ -inch apart, then a series of passes to clean out in-between.

The upper and lower side pieces are dadoed $\frac{3}{4}$ -inch wide and $\frac{3}{8}$ -inch deep to receive the horizontal members and drawer shelves. A $\frac{1}{4}$ -inch rabbet cut is made at the inside back of the top, bottom and side pieces. The drawer shelves and top of the lower cabinet are not rabbeted since they were cut $\frac{1}{4}$ -inch narrower at the onset. This is to allow the back panel to set in flush. *Note:* The bottom member of the cabinet is $\frac{3}{4}$ -inch fir plywood; the front edge faced with a one inch length of birch.

Although some craftsmen like the ef-





fect of the exposed raw edge of lumber core, the trick used by the pro's to conceal the edge is to simply add on a thin strip of solid stock about 1/8-inch thick. After all panels are cut to size, rip up a supply of such strips and glue onto all front edges of the panels. Sand flush to sides.

Assembly and gluing are the next steps. Use of white glue is recommended because of its good holding, quick setting, and nonstaining characteristics. Use 1 1/2-inch finishing nails for holding the parts while clamps are affixed to the work. In a number of places the nails will eventually be concealed by the molding trim; elsewhere they should be set and the holes filled with Plastic Wood or similar material. If you do not have large clamps to handle the job, you'll have to resort to the use of flat head wood screws to provide gluing pressure. Here again, holes will require

filling after the screws have been countersunk.

The base of the unit is made of 3/4-inch solid stock, birch or maple being equally suitable. If a less expensive wood is preferred, basswood or poplar can be used. This applies to the trim as well. Cut the parts for the base noting that the dimensions allow for the cabinet to set into the base. Thus the inside dimensions of the base wall are equal to the outside dimensions of the cabinet. Cut a 3/8-inch dado 1/4-inch deep and 1/4-inch from the top of the three pieces (two sides and front) before gluing. Since the 3/8-inch set-in panel will add much strength, ordinary butt joints will suffice between front and sides. The curved cross-section of the base is accomplished by hand planing to shape. If a planer jointer is available, so much the better.

Fancy treatment of the cabinet doors

Building a Colonial Hutch

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is next. This is a rather simple operation. The curved molding (which is sold as a set of four pieces to a package) is positioned at each corner 2-inch from each edge and the outline is marked lightly in pencil. A couple of $\frac{5}{8}$ -inch brads are nailed about two-thirds of the way into the panel. The heads are then clipped off with diagonal cutter or pliers to form a point of sorts. The molding is again put into place and pressed lightly to get an impression of the nail positions for drilling. Drill same-size holes, apply a few small beads of glue and finally press the corner firmly into place. The protruding nail points will usually suffice to hold the molding in place while the glue sets. If not, apply clamp pressure.

Inasmuch as the ends of the corner molding are pre-cut to a 45° angle you will need only to cut matching 45° angles on the straight lengths and apply, following the same procedure as for the corners.

Butt hinges are set into mortised recesses in the door so they will lay almost flush

with the edge. This will eliminate the need to mortise on the cabinet side. Position the doors so they will set back $\frac{1}{8}$ -inch from the cabinet front and measure and mark for hinge screw holes. Before finally attaching doors, make the partial saw cut $\frac{3}{8}$ -inch deep across both doors, 6-inch from the top to simulate the drawers.

The upper drawer is a simple box construction made with $\frac{3}{8}$ -inch plywood to which the front panel is attached. Accent molding is made by cutting the pattern on shaper or saw with sharper cutters. Rip down the lengths required using 45° miters for corner joints, then nail and glue into place. Set all nails and fill the holes.

Addition of the decorative fence and valance on the upper shelf completes construction. Screw the three sections together for rigidity, glue in the back panel ($\frac{1}{8}$ -inch birch plywood) and smooth-sand the entire job. Stain to suit and surface with several coats of satin brushing lacquer for a fine, lasting finish. J.C.

See also: FINISHING, WOOD; WOODWORKING.

MATERIALS LIST

Quantity	Size and Description	Purpose
1	$\frac{3}{4}$ " 4'x8' birch lumber core plywood	basic unit
1	$\frac{3}{4}$ " 12 $\frac{1}{2}$ "x33 $\frac{3}{4}$ " fir plywood	lower section bottom
1	$\frac{3}{8}$ " 9 $\frac{3}{4}$ "x32" fir plywood	drawer bottom
2	$\frac{3}{8}$ " 3 $\frac{1}{2}$ "x32" fir plywood	drawer back and front
2	$\frac{3}{8}$ " 3 $\frac{1}{2}$ "x9" fir plywood	drawer sides
1	$\frac{3}{8}$ " 13 $\frac{3}{4}$ "x34 $\frac{1}{4}$ " fir plywood	base
1	$\frac{1}{8}$ " 33"x62 $\frac{1}{2}$ " birch plywood	unit back
1	$\frac{3}{4}$ " 5"x35 $\frac{1}{4}$ " solid birch	base front
2	$\frac{3}{4}$ " 5"x13 $\frac{1}{2}$ " solid birch	base sides
7	$\frac{1}{4}$ "x2" round dowel	upper section fence
8	$\frac{1}{2}$ " curved corner molding	doors
	$\frac{1}{2}$ "x12' molding to match above	doors
	$\frac{1}{8}$ " $\frac{3}{4}$ "x30' solid birch edging	front edges
	$\frac{3}{4}$ " $\frac{3}{4}$ "x20' birch molding	

NOTE: Also need butt hinges, door pulls, drawer handles, $\frac{1}{2}$ " finishing nails, stain and finishing coat.

Dutch Colonial Seats for Your Front Porch

By adjusting the dimensions to suit the place, these seats will add an old-world touch to your home

THE SMOOTH sweeping curves of these graceful Dutch seats will add charm and livability to the front porch of almost any frame house, as well as to many porches that have been added to brick homes.

Two designs are suggested. The simple style can be used on one side of a deep porch, or as a twin design on a shallow porch. You will find that the paired curves on each side will frame and emphasize the doorway. With a single bench, use the shelves with potted plants or decorative pottery. The shelf brackets repeat the curved shape of the bench for good artistic effect.

Your first step is to measure your porch floor. The width of the colonial seat depends on your porch size. Plan your dimen-

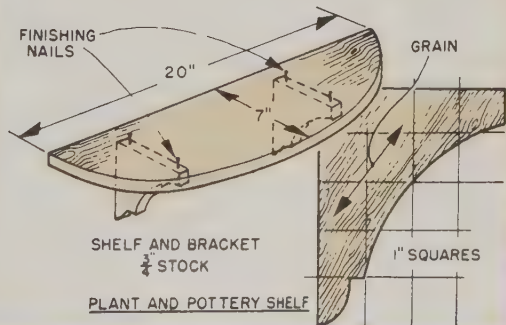
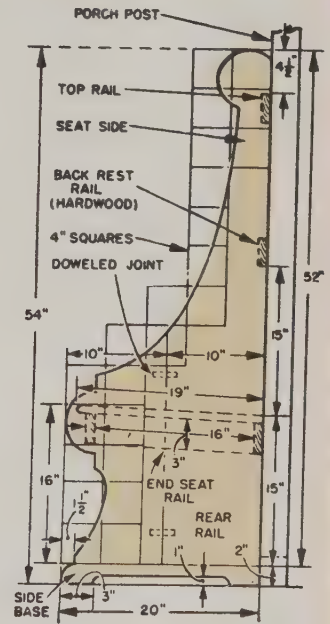
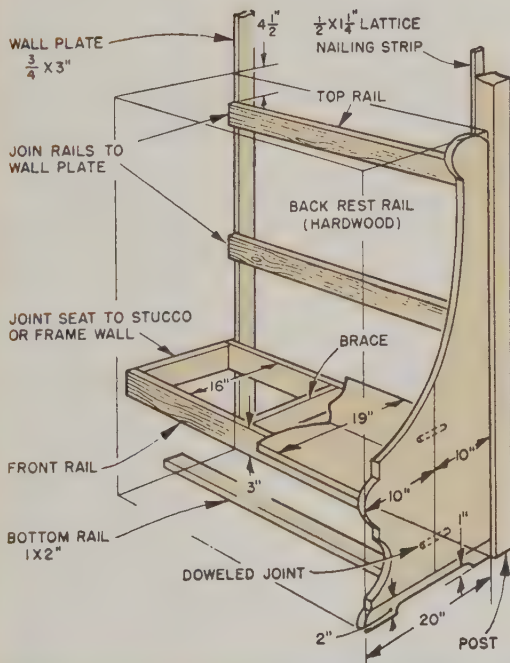
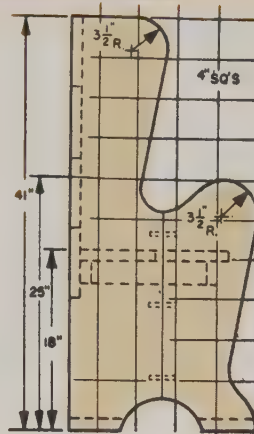
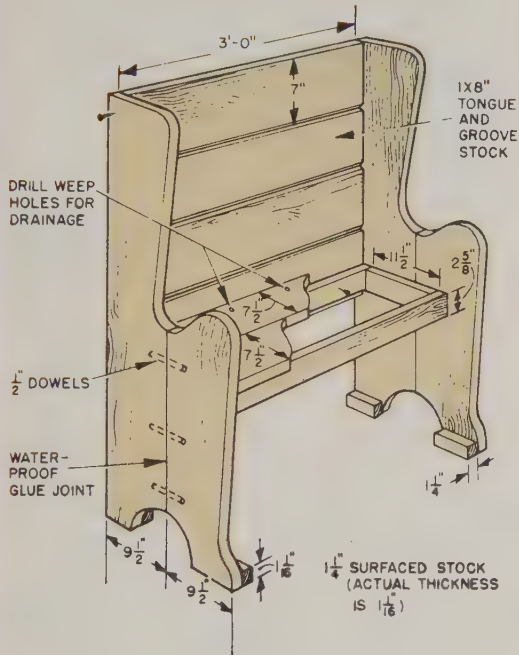
sions so that the overall width of the seat and ends is just right for a close fit between the wall and the porch post.

For economy, use pine lumber; it will be serviceable for years if you keep it well painted. A better, but more costly choice would be the heartwood of a decay resistant wood such as cypress or redwood. For a narrow seat about four feet wide, 1½-inch thick surfaced lumber would suffice, but for wider seats use 1½-inch stock.

To draw the curves, lightly pencil 4-inch squares on the lumber as a guide. Saw the outline and sand. Use waterproof glue and rust resistant screws for assembling the joints.

On concrete porches, you will want to anchor the bench permanently in place. Drill holes through the bottom cleats, mark the right spots and use a star drill and concrete anchors. Paint the finished bench to match the house, but be sure to undercoat first according to the paint makers instructions.

See also: FINISHING, WOOD; PAINT; PAINTING; WOODWORKING.

Dutch Colonial Seats for Your Front Porch

Build a Colonial Canopy Bed

This pine colonial canopy bed is easy to build and adds a warmth to your bedroom that will never go out of style

FASHIONS that are going out of style now will be back in years to come. This applies to clothes, hair styles—and furniture.

The pine canopy bed shown here is a case in point. Its dignified 18th Century quality is bound to please those who prefer traditional furniture to modern. And like so many other home workshop projects, it can be built for a fraction of what its commercial counterpart would cost.

The four corner posts are the biggest job, so start working on them first. Since it is impossible to turn these 63 $\frac{3}{8}$ -inch-long posts on the ordinary lathe, you will have to make them in two sections and then join the sections.

Rip the 1 $\frac{3}{4}$ -inch pieces of pine to two-inch widths and 36-inch lengths for the upper and lower pieces. The bottom sections will be 32 inches long after they are turned, and the top sections 32 $\frac{3}{8}$ inches. In addition you will have to make $\frac{7}{8}$ x 2 $\frac{1}{2}$ -inch dowels which will join all of the top and bottom sections.

Mark and cut both the mortises and the holes for the dowels before going ahead and turning the post sections on the lathe. The holes in the bottom sections are 1 $\frac{1}{2}$ -inch deep, and in top sections one inch deep.

Before assembling the sections, mortise the lower halves of the posts to take



the headboard and footboard crosspieces, and the top of the two head posts for the headboard.

Next, turn the two sections of the footboard rail, also ripped from 1 $\frac{3}{4}$ -inch stock. The rail has 1 $\frac{1}{8}$ -inch tenons at each end which fit into holes drilled in the posts, and where these two sections are joined, each has a two-inch hole to accept half of the four-inch dowel. Glue turned rail and 8 x 37 $\frac{1}{2}$ -inch footboard into their respective holes and mortises.

Three boards glued together make the headboard. To be sure of strong joints where the three boards join, use $\frac{1}{4}$ -inch plywood splines set in the grooves, which are cut with a router. Use a table saw to cut the tenons for the headboard.

When working on the bed rails an important concern is the strength of the metal brackets, since most commercial furniture has a more elaborate system for holding the bed rails in place. However, by using $\frac{1}{4}$ x 1 $\frac{1}{4}$ -inch carriage bolts and drilling through both the bed rails and the brackets (after first determining their correct position), the problem can be solved.

The next step is to position the bed rails against the completed footboard and headboard and make a light outline of the brackets on the posts. This will mark the position of the steel pins that support the bed rails in each post. Cut the grooves

Build a Colonial Canopy Bed

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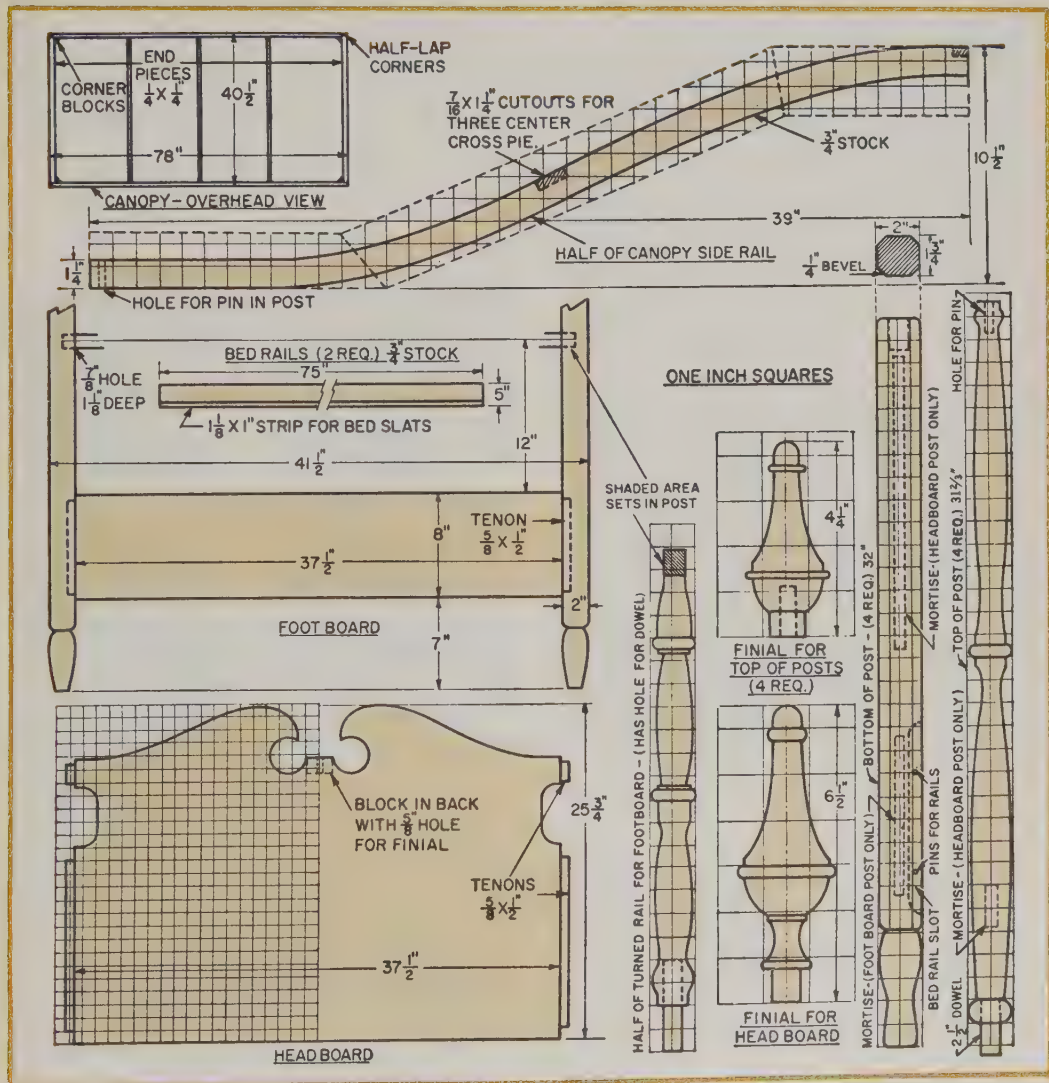
in the posts for the brackets before assembling the headboard and footboard. Then drill holes in all four of the posts for the pins, drive the pins below the surface and plug the four holes with dowels.

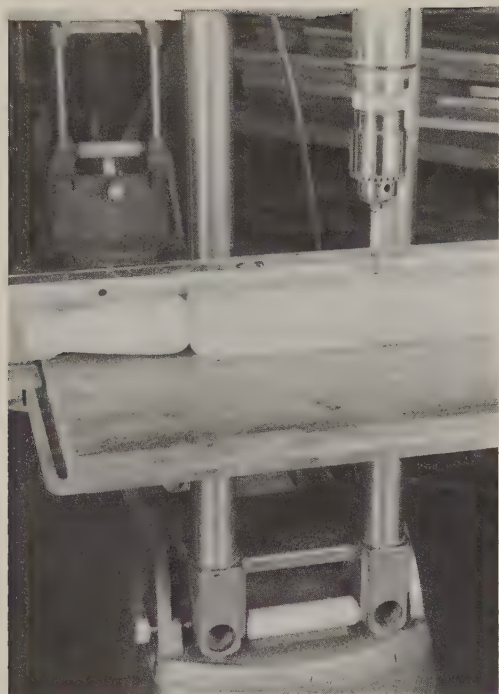
Now begin working on the canopy frame. By laying out a full-size view on a piece of plywood, you will find it easier to do the actual construction. For each side piece use five separate cuts of wood, each three inches wide, splined together. Three of the crosspieces are $\frac{7}{16} \times 1\frac{1}{4}$ -

inch, but the two end ones are larger ($1\frac{1}{4} \times 1\frac{1}{4}$ -inch) for added strength. The corners can be strengthened by gluing in corner blocks.

After completing the canopy turn to the last items, the finials. The large one is mounted in a $\frac{5}{8}$ -inch hole drilled into the block glued to the back center of the headboard (see drawing). The other four are smaller and fit over pins protruding from the posts.

Thoroughly sand all the pieces and spray





▲ Drill holes in the lower halves of posts for pins to hold the bed rail brackets in place.



▲ Footboard of bed before top sections of posts are added. Rail is made in two sections.

an alcohol-base stain on the entire bed to give it that Early American look. Then apply a semi-gloss, alcohol-resistant-type lacquer. After the first coat has dried, lightly steel-wool the entire bed, and give it a final coat of clear lacquer. E.P.K.

See also: FINISHING, WOOD; WOODWORKING.



▲ Headboard and posts before mortises are cut in posts for tenons. Note bracket grooves.



▲ Bed rails are attached to posts. The brackets are secured to the rails by carriage bolts.

Egg Masterpieces are Easy to Make

By following these basic techniques and using your imagination you can decorate eggs that are attractive all year round

THE CRAFT OF TRANSFORMING eggshells into decorative and functional items is rapidly increasing in popularity. Practically all cultures have been fascinated by and have made use of the nearly perfect shape and structure of the egg. The Central Europeans developed a method of using a wax resist to decorate eggs. After the resist was applied, the egg was colored with natural dyes. The wax was removed and the dyed design was left on the egg. Late in the 19th Century, the jeweler, Fabergé began creating eggs with moving parts made from precious metals and jewels. These eggs were produced in his workshop at the rate of only one a year.

Egg decorating is quite simple to do. It requires only a few tools and ideas. Neatness and exactness of workmanship are the determining factors of the quality of the finished project.

Eggs vary as to size, color, texture and availability—eggs are more readily available in the spring and early summer. The eggs most commonly used in decorating are chicken eggs, the smallest and most commonly used; double yolk chicken eggs (roadside stands are the easiest place to find these); duck eggs, third in size with

a smooth and cream colored shell; turkey eggs, marked with speckles which can be removed with a scouring pad; and the large goose eggs with beautiful smooth white shells available through mail order or hatcheries.

Materials which can be used in decorating are lead shot, paints, gold paper, lace, gold braid, pearls and beads, pins, ribbons, rhinestones, sequins, satin balls, hinges and virtually anything your imagination can conceive.

There are several methods of cutting egg shells, but the best, though most expensive, is a small high-speed hand drill with a cutting wheel. A very sharp knife or a single edge razor blade will score the shell, but you must carefully pull the edge of the blade back and forth over the line you want to cut. Manicure scissors can also be used.

There are certain basic step-by-step techniques which will give you the best results. By following these rules, you can depart at any time to follow your own design creation.

First, place a clean dish or plate under a fresh egg. Hold the egg in one hand, and using a sharp slender pin, prick a small hole in the egg. Enlarge the hole to about ¼-inch by breaking away the small pieces of the shell. Use small manicure scissors to enlarge the opening, and rotate the shell as you cut a strip about ⅛-inch wide. If you try to cut a wider strip, you may break the shell. When the opening in the shell is as large as you want, remove the shell pieces from the egg and

pour the egg out. Try not to tear the membrane as this gives the shell added strength.

If you leave the membrane in, kill bacteria in the shell by pouring some disinfectant liquid in it. Then, with your hand over the opening, shake it carefully.

If a piece of the shell happens to break, it is possible to mend it. All you need is clear nail polish and a piece of rice paper, cut $\frac{1}{2}$ -inch larger than the break, on the inside of the shell (while the polish is still wet). Put another coat of polish over the paper and press the broken piece of shell onto the paper. It will look as good as new when you have coated the patch with polish on the outside of the shell.



Egg Masterpieces are Easy to Make

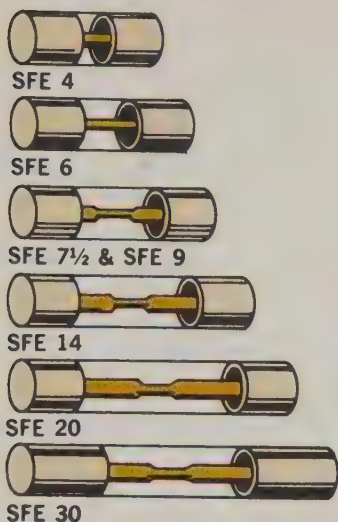
To hold the shell while painting, place two fingers in the opening of the shell so it can be held firmly. Use a soft brush and apply at least two coats of paint to achieve a uniform color. Use acrylic paints as they dry quickly and cover well. When the paint has dried, apply a protective coating of a clear finish. The clear coating will also give a nice glaze to the outside of the egg.

Greeting cards are an excellent source for small pictures and background scenes. Select the scene that you want to use, and draw an outline around it in the same shape and size as the opening in the egg. Cut out the design (inside the line) and push it to the back of the shell through the opening. Heat a small amount of paraffin wax to approximately 150° and pour the melted wax into the shell and swirl it around until it completely covers the inside of the shell. (Tinted wax can also be used). This waxing step will seal the scene to the back wall of the egg. Once coated, pour the wax out quickly so it will not drip on the outside of the shell.

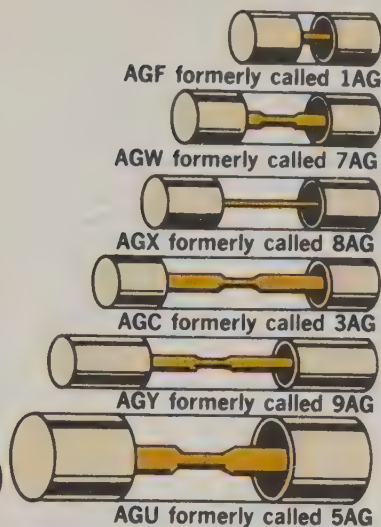
If you are using a small cut-out for the foreground, dip it in the warm wax with tweezers. Here, the wax acts as glue to hold these small figures in place. While the wax in the shell is still warm, put the cut-out in place and press with your finger. Remove all the wax that dripped onto the outside of the shell when it cools, as then it is easy to peel off. From here, the decoration ideas are all yours. You can find some gold braid with adhesive backing, tiny pearl strings, or beads and put them around the outside of the opening to "frame" it.

These or any other objects you have in mind can easily be glued in place. There are an endless number of attractive designs which are just this easy, but appear as though you have been working all week. Simply use your imagination and whatever you have lying around to create masterpieces of art from eggs.

NEW STANDARD FUSES



OLD TYPE "AG" FUSES



Servicing Electrical Controls in Your Car

If the cigarette lighter is broken or you are having trouble with the radio, it may be the fuses. These few simple checks can test the circuits of the entire electrical system in your car

MOST CAR OWNERS have experienced blown fuses in their homes and know where to go and how to remove the damaged fuse and replace it with a good one. Your car's light and electrical-accessory wiring system is not very different from your home's and if you carry several new fuses—and know where the fuses are located—the job of handling a blown fuse is simple.

Correcting the trouble that was responsible for the fuse blowing, however,

is not always so easy. Besides, an electrical system, such as wipers or a clock, may be protected with a "circuit breaker," which, unlike a fuse, does not "blow," but intermittently opens the circuit to reduce the current and serve as a warning that a "short" exists and something must be done about it.

The small fuses used on cars are of the cartridge type and slip into fuse clips or in-line retainers. Do not attempt to remove fuses with a screwdriver; you may touch one clip with the screwdriver's blade and at the same time ground the blade on nearby metal. The resulting sparks may not only startle you badly, but on a 12-volt system could instantly burn out every wire under the instrument panel, since the overload factor inherent in the older 6-volt systems is missing. Use a small wooden stick to remove the fuses. Better still, purchase a small, inexpensive plastic or hard-rubber fuse puller that permits

electrical circuits: see circuits, electrical
electrical systems, home: see electricity
electrical terms: see electricity
electrical wiring: see wiring, electrical
electric heating: see fuels

you to get a good grip on a cartridge fuse. It must also be completely insulated. Such pullers are available at auto supply stores.

Suppose that the electric clock in your new car does not work. You go about trouble-shooting it as you would if the lights in your home go out. You look for a blown fuse. A chart that tells you the size, type and location of car fuses is available. Once the fuse is located, you can tell by looking at it that the link inside the glass casing has melted to interrupt the circuit. Occasionally, clock fuses are in the line and you have to undo the bayonet lock on the fuse housing to drop out the fuse. If the fuse is blown, replace it with one of correct type and size. Correct fuse amperage is important. Installing a fuse of greater capacity than specified may damage the unit it is intended to protect.

The single-wire system, wherein the metal parts of the car serve as a return wire or ground, is universally used on cars. With the switch on a car lamp closed, the circuit to and from it is complete and, con-

Servicing Electrical Controls in Your Car

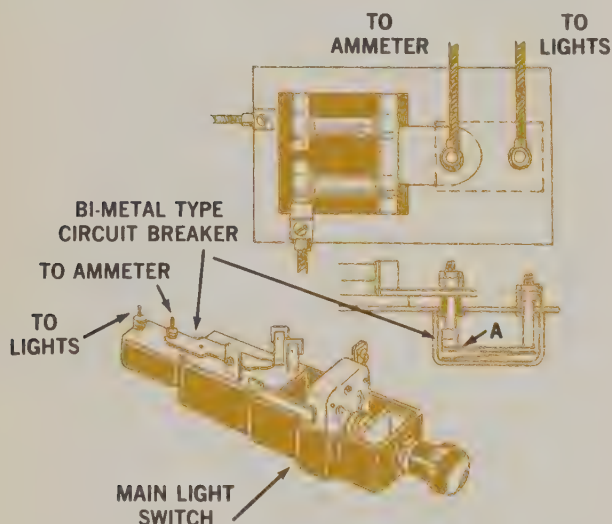
sequently, the lamp lights. If a connection to the lamp loosens, becomes corroded, or begins to chafe, resistance is set up in the circuit, heating occurs, the lamp burns dimly and—if the wiring grounds—the battery will discharge. Heavy discharge reading on an ammeter would warn of this, but if a light is used instead of an ammeter (as is common with later model cars) a very heavy short would be required to cause the lamp to glow.

If such a simple circuit is protected with a fuse, however, any of the conditions mentioned above will melt the fuse link, breaking the circuit, thus protecting the units and wiring and preventing danger from fire.

To locate the cause of a blown fuse, always check wiring terminals for tightness first. Look for spots where a wire is rubbing against a sharp metallic surface. And if you do put in a new wire, don't let it hang loosely. Tape it wherever possible to a bracket, or insert it in the regular clips made to hold it.

If any of the car lamps fail to light and the bulb is known to be okay, then it can be due to a blown fuse and replacement often restores the circuit. If a second fuse blows, the trouble lies elsewhere in the circuit. A vibrating circuit breaker always means a short which you must find and correct. To do this, disconnect the switch wires one at a time until the relay stops vibrating. That is the line or wire in which the trouble will be found. If you get no light and the lamps are working properly, the circuit breaker contacts could be disengaged. Replace an open circuit breaker. You will also find that electrical circuits will work better if you occasionally take out the fuses and clean the fuse clips and the ends of the fuses to remove corrosion.

The lighting system is the largest and most involved in wiring and the likelihood of shorts or grounds. The circuit basical-



▲ Circuit breaker has been used for lights, and is now primarily used for accessories, such as windshield wipers. Cutaway and schematic show how it works. Circuit breaker is usually built into a switch, as illustrated.

Servicing Electrical Controls in Your Car

ly includes head lamps, parking lamps, tail-lights, spotlights, directional lights and interior lamps. It is often supplemented by spotlights, back-up lights and fog lights; all of these circuits usually being fused. Fuses are also used in the accessory circuits such as heaters, radio, underhood lights, hand brake lights, cigarette lighters, overdrives, trunk lights, air conditioners and many other units.

Fuses are seldom used for headlamps, except in very old cars and trucks. Protection for headlamps, taillamps, parking lamps and instrument lamp circuits on most older cars is through a thermostatically-controlled limit relay or a bimetal type circuit breaker, usually attached to the main light switch. On most cars built in the last few years, all circuits but the headlamps have been removed from the circuit-breaker line and are fitted with separate fuses. The reason for this is that the headlamps and taillamps are used the most, and are the most important in the operation of the car.

Headlamps, generator and the entire battery system on today's cars are protected by "fusible links." A fusible link is nothing more than a piece of wire that is spliced into a circuit in which the wiring is one or two standard thicknesses larger. For example, a piece of 14-gauge wire is spliced in, to protect a 10-gauge wire circuit.

This piece of wire is often covered by a plastic sheath of special shape for easy identification.

If the circuit is overloaded, the higher-number (thinner) wire burns out and separates, just like a fuse.

The location of these links varies according to the make of car. On late-model Chevrolets (except Corvette), for example, there is a 16-gauge black fusible link to protect all unfused wiring of 12-gauge or thicker. This link is at the horn relay.

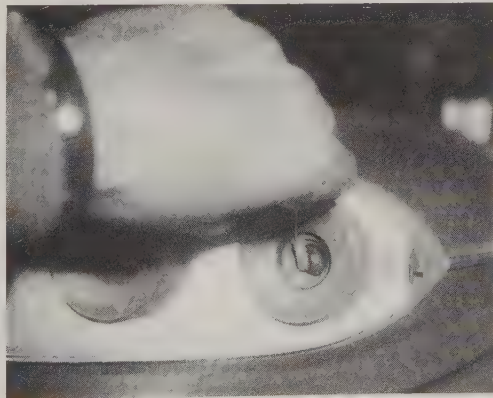
The generator warning light and gener-



▲ Removing a fuse with a screwdriver is risky, as screwdriver might touch another fuse's clip or an electrical ground and cremate some car wiring. A wooden stick, such as from an ice cream pop, is the best choice.



▲ Headlamp is checked by connecting two or three terminals to battery posts, using jumper wires. By trying all three possible combinations, you should get low and high beams to work.



▲ Corrosion and rust are usual causes of socket failure. Clean with a wire brush.

ator field circuit, which is 16-gauge, is protected by a 20-gauge fusible link, also at the horn relay.

If a fusible link breaks, the repair (after correcting the cause) is to splice in a new piece of the appropriate gauge wire, solder or crimp-connect the terminals and tape over with plastic electrical tape.

Remember that the wiring circuits in your car are like those in your home. If you have too many lights and appliances on one circuit, a blown fuse will result. The same thing is true in a car. Using a larger capacity fuse will prevent a blown fuse, but trouble is built in. The best method is to run a new circuit, with its own proper capacity fuse, to protect the new spotlight or other accessory. In some cases there is a junction block wired to the ignition switch that has spare connections that can be used. This heavy-duty circuit will handle the additional electrical load, and also has the advantage of shutting off the current when the ignition key is turned off.

Although sophisticated electrical troubleshooting is for the professional, most problems are not all that sophisticated.

If a bulb circuit fails to operate, there are five possible causes:

1. Bad bulb.
2. Poor connection at the socket or bulb terminal.
3. Defective wiring.
4. Defective switch.
5. Blown fuse (if the circuit is fused).

Clearly, a wiring problem is only 20 percent of the possibilities, and in actual practice, occurs perhaps five percent of the time.

Checking a bulb is simple. Attach a jumper wire to one terminal of the battery. Sit the bulb on the other battery post, holding it so that its bottom terminal is in contact. With the jumper, touch the metal side of the bulb. If it is good, the bulb will light.

To check a headlamp, which has three terminals, the procedure is similar. Con-

Servicing Electrical Controls in Your Car

nect any two terminals to the battery posts in the three different combinations possible and you should get a low beam and high beam.

A socket can be checked with a test lamp. With the appropriate switch on, one lead goes to the metal tab contact in the center, the other to the cylindrical metal side. If the lamp lights, the socket is good.

Corrosion and rust are the usual causes of a socket failure, and if you see any, clean with a wire brush.

Corrosion not only affects sockets, but fuse contacts as well. If you see a white corrosive coating on the fuse contacts, also clean with a wire brush.

Wire and switch terminals are still another area corrosion can affect, causing a poor electrical connection. You are probably familiar with the effect of corrosion on the battery cable connections, and how this can interfere with engine starting by restricting the flow of current.

Plainly, if current cannot get to a light or accessory, it will not work. Even if a connection is physically tight, it may be electrically weak if corrosion is present.

Poor connections can also be caused by loose terminals which you can physically feel, particularly on a switch.

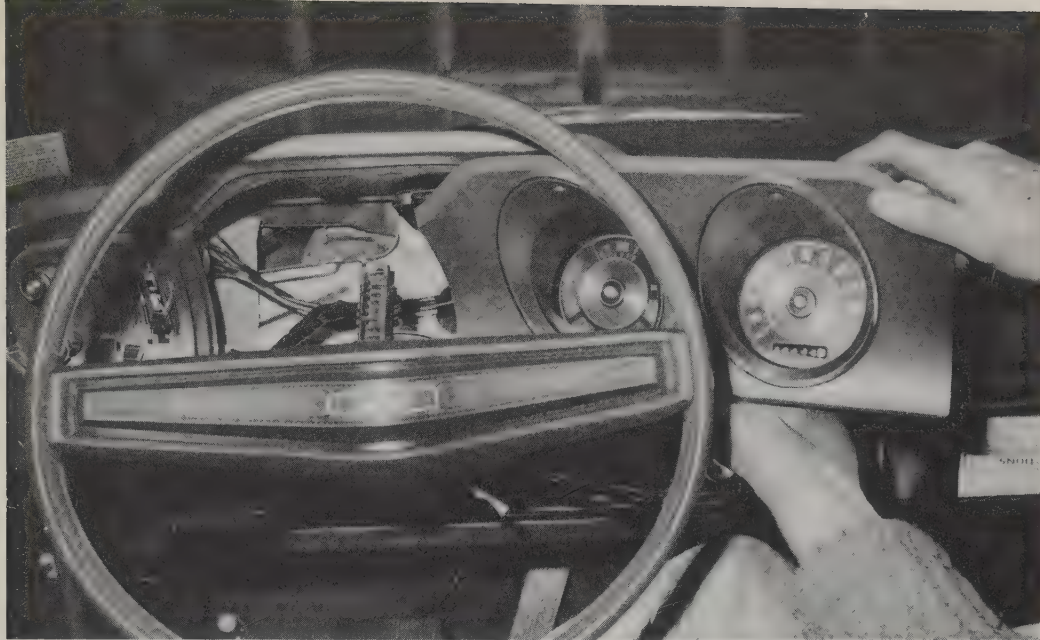
A switch may also have an internal break. This can be checked, but like the defective wiring problem, is best left to an expert. If you can get a replacement switch on a "return it if I don't need it" basis, you can check the old switch by substituting a new one.

P.W.

See also: ALTERNATOR, AUTO; BATTERIES.

WHERE TO FIND IT

A chart that tells you the specified size, type and location of car fuses for all makes and models of cars for the last 15 model years is available from Bussmann Mfg. Division, McGraw-Edison Co., Post Office Box 14460, St. Louis, Missouri 63178.



Checking Dashboard Gauges in Your Car

The gauges in the instrument panel are designed to warn you of something faulty in your car, but if they are not working properly a small problem can become a costly nightmare

THE MAN WHO likes to take care of his car is also the type of person who will order his new car with every optional dashboard gauge available so he can spot problems before they get serious.

Yet problems can also occur with gauges. Not too long ago, pulling an instrument gauge cluster and putting it back was a time-consuming horror.

Today, many cars have quick-pull instrument clusters. General dashboard gauge accessibility on almost all cars is markedly improved.

In many cases, problems can be cured without removing a gauge or cluster.

Electric circuit: An electric gauge circuit is usually quite simple. One wire (or printed circuit) goes from each gauge into a master connector, and one wire from that connector goes through a fuse to a terminal on the ignition switch. Another wire goes from the gauge to a sensor (also called a sending unit), on the engine for water temperature or oil pressure, in the gas tank for fuel level.

General Motors cars use a conventional 12-volt circuit. Ford and Chrysler products have gauges designed to operate on five volts, and the wire from the ignition switch to the gauges is split and a special voltage regulator is inserted in the circuit. This special regulator keeps voltage to the gauges at the specified five.

This special regulator is mounted under the dashboard, on the back or top of the cluster on Ford products and some Chrysler cars. It is also built into the fuel gauge on

other Chrysler products. (If you check with a parts house, you'll find out if the special instrument regulator is a detail or only available with a fuel gauge.)

Gauge operation. The electric gauge operation, regardless of function, is basically the same. In the fuel gauge, for example, the fuel in the tank controls the position of a float, which is attached to a variable resistor with a movable contact.

When the fuel level is low, the contact is moved by the float to a high resistance portion of the resistor, limiting current that can flow from the ignition switch to the gauge.

When the fuel level is high, the float moves the contact to a low resistance portion of the resistor, allowing more current to go to the gauge.

The gauge itself has a pointer controlled by a bimetal strip, which is heated by the current flow from the ignition switch. When the current flow is low, there is little heat and the pointer moves only a bit. When the current flow is high, the bimetal strip is heated more, and deflects the pointer further along the gauge.

The temperature gauge system is different only in that a temperature-sensitive resistor is used as a sending unit. When engine temperature is low, the temperature-sensitive resistor produces high resistance for minimum deflection of the gauge pointer. When engine temperature rises, the temperature-sensitive resistor's contact is moved to a low-resistance position, permitting greater deflection of the gauge pointer.

The oil pressure gauge sending unit uses a pressure-sensitive flexible diaphragm to control the movable contact in a variable resistor.

Common problems. The most common gauge problems are:

1. No gauges work at all.
2. All gauges are pegged, that is, all the way to the high end of the scale.

Checking Dashboard Gauges in Your Car

3. A single gauge of the group fails to function.

Failure of any gauge to work is common, and is usually nothing more than a blown or defective fuse. Fuses are cheap so, even if a fuse looks good, try replacing it before attempting anything more complex. (You can "borrow" a fuse from another circuit. Just make sure it is of the same amperage rating.) Some fuses that look good have suffered a separation at one of the metal cap ends.

Another possibility is a break in the circuit from the ignition switch to the master connector to the gauges. On GM and American Motors cars, check for a loose connection at the ignition switch.

On Ford and Chrysler products, the loose connection is possible, but it is more likely a defective instrument voltage regulator that is responsible for the trouble.

Test regulator. To check the regulator, disconnect the wire from the engine temperature or oil pressure sending unit in the engine, whichever is more accessible.

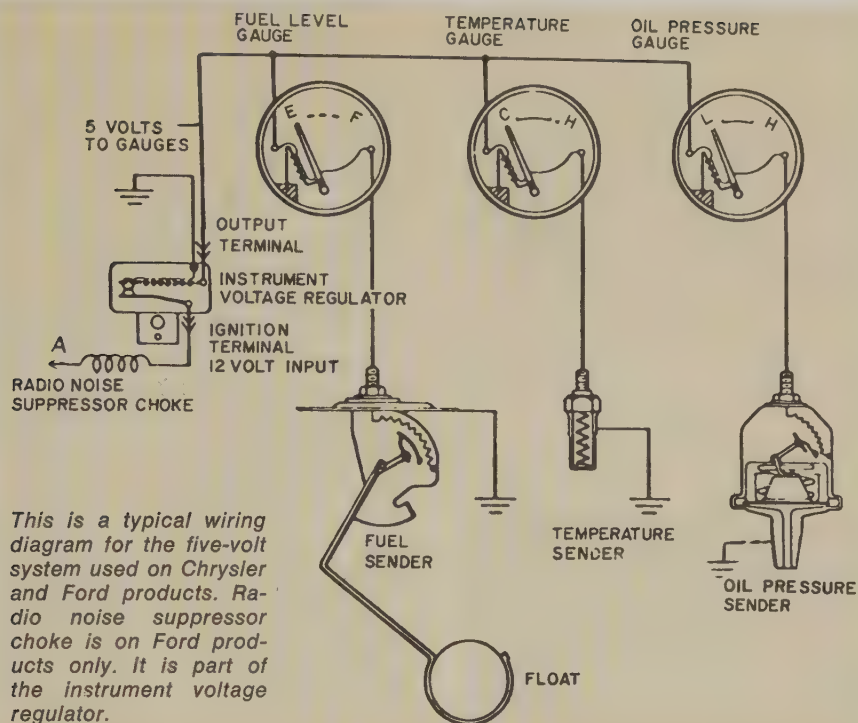
Connect a test lamp in series—one wire of the test lamp to a good ground, the other test lamp wire to the terminal of the wire you took off the sending unit.

Turn on the ignition. The test lamp should flicker if the instrument regulator is good.

If you have a voltmeter, make the same connections and if the regulator is good, the voltmeter needle should flicker.

If the regulator is defective, it must be replaced. It is a sealed unit and cannot be serviced. See the illustrations which show the unit and its mounting.

If the regulator tests out well, and the gauges still don't work, the problem must be in the master connector to the gauges or in the printed circuitry on cars so equipped. If you can't find an obviously bad connection, leave the job to an electrical specialist. Fortunately, 98 percent of the time, the problem will be in the areas you can handle.



Some Ford instrument regulators incorporate a radio suppression device called a "choke," and if this is defective, it can cause all gauges to stop functioning. To check the choke, see the illustration.

Pegged gauges. (This applies only to Ford and Chrysler five-volt systems.) If the gauges all are pegged, there are two possible causes:

1. The instrument voltage regulator is defective (you now know how to check that out).
2. Whatever is used to ground the regulator and gauges is not providing a satisfactory ground connection.

The regulator and gauges usually are grounded by the mounting screws, and if they are loose, the ground circuit is poor. A poor ground circuit provides a false signal to the instrument regulator and causes it to pass higher voltage.

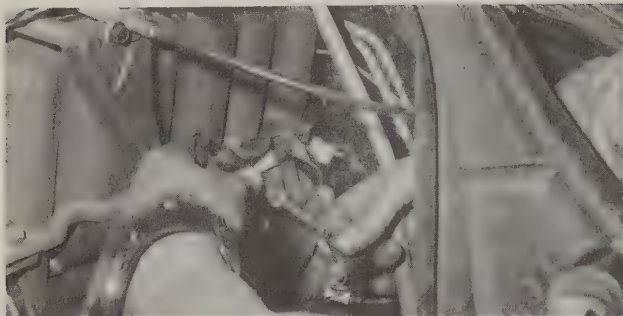
Jumper wires from the instrument



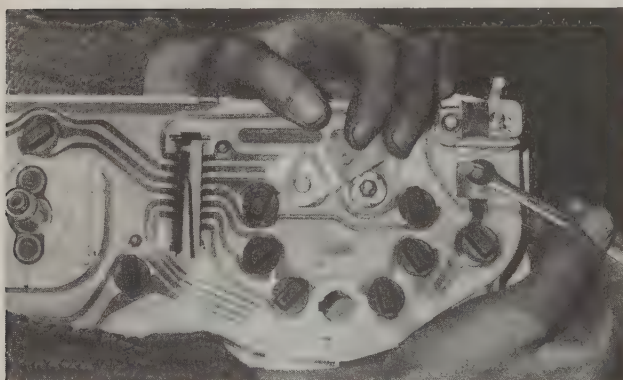
▲ The back of a Maverick instrument cluster. Plastic sheet with printed circuit is used instead of wiring. Finger points to location of instrument voltage regulator at upper right.

regulator body and the instrument cluster to a good ground can be used to pinpoint the problem. If the use of jumper wires causes the gauges to operate properly, tighten the mounting screws.

If the problem was cured with jumper



▲ Instrument regulator can be checked by disconnecting a sending unit on engine (oil pressure sender is one disconnected in photo) and connecting a test lamp (alligator clip to ground, probe to wire from sender). Turn on ignition; if regulator is good, test lamp bulb should flicker.



▲ Unsnap two buttons to expose instrument regulator and unbolt as shown to remove.



▲ On models without printed circuitry, instrument voltage regulator may be a plug-in unit.

wires but will not go away when you tighten the screws, run separate jumper wires.

Checking Dashboard Gauges in Your Car

Individual gauges. If an individual gauge does not work, the problem is in the sending unit, the wiring or the gauge itself. The common problems in the wiring are poor or loose connections, which can be checked visually.

To check out a gauge, disconnect the wire at the sending unit, and connect it to ground by means of a jumper wire with a 10-ohm resistor in it. You can make such a jumper wire with a 10-ohm resistor purchased from a radio supply store, a couple of pieces of wire and a couple of alligator clips. Attach one end of each wire to a terminal on the resistor, and the alligator clips to the other ends of the wires.

With the sending unit wire attached to the special jumper wire and the wire connected to ground, the gauge pointer should swing all the way to the high side. If it does not, the gauge is defective and should be replaced.

If the gauge is good, check the sending unit for a good ground by connecting a jumper wire (without the resistor) from the sending unit body to the engine. If the gauge now operates normally, take out the sending unit, clean its threads and the sending unit bore with a brush and reinstall.

If a bad ground is not the problem, and the gauge is good, the odds are that the problem is a defective sending unit. The only practical way to test one is by substituting it with a new unit. With a fuel sending unit, this requires dropping the gas tank, a somewhat time-consuming procedure. But your time is a lot cheaper than a professional mechanic's, and sending units, fortunately, are inexpensive.

Special problems. Other possible gauge problems and their solutions are:

1. Flickering gauges. This is usually limited to cars with five-volt systems and can be caused by bad contact points in the instrument regulator. Replace it.
2. Individual gauge is pegged. This is

Checking Dashboard Gauges in Your Car

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caused by a shorted wire in the harness or a shorted sending unit. The more common situation is a shorted sending unit, which should be checked by substitution. If the sending unit is good, the only practical cure is to disconnect the wire from the sending unit to the master connector, tape it at both ends and run a new wire outside the wiring harness. Although the wiring problem could be checked with a jumper wire, eliminating the possibility of unnecessarily buying a sending unit, it is somewhat remote and may be very time-consuming on older cars. If you have a car with a quick-pull instrument cluster, the job can be done easily, provided you have a wiring diagram and can identify the one in the master connector that provides juice for the offending gauge. This job can present problems and you may wish to leave it to a professional.

3. All gauges read low on Chrysler or Ford five-volt system. The problem is normally a defective instrument voltage regulator.

Horn switch. By installing a simple push-pull switch on your dash, and cutting into one wire, you can be certain that your car horns will never blow at midnight.

First, drill a hole large enough to accommodate the switch at a convenient spot on the dash. Lift the hood and locate the horn relay. If you're unsure about which metal box is the horn relay, trace the wires from the horn. Take two lengths of #14 insulated wire and thread them through the firewall, if possible, using a hole in the firewall through which other wires pass. If you drill a new hole, install a rubber grommet so the insulation on the wires won't scrape against metal.

Loosen the screw on the horn relay terminal marked "S" (switch or horn button) and remove the wire from the horn relay. If there is no "S," the smallest wire leading to the relay is the horn ring, or button, wire.

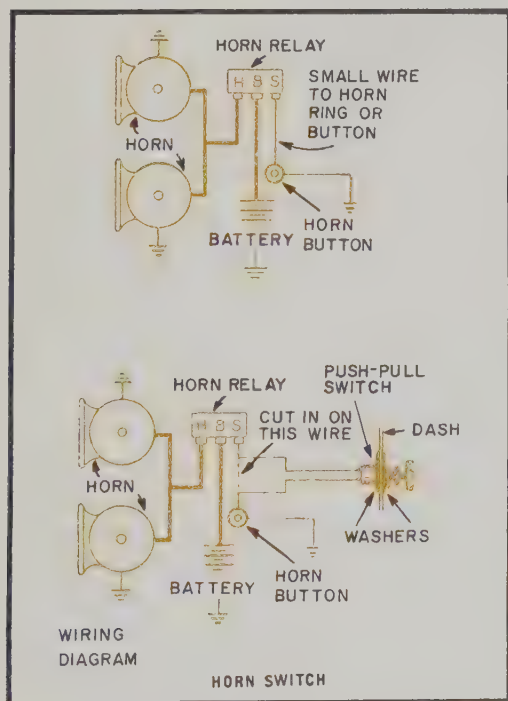
Attach one of the new wires to the "S" terminal on the relay; lead the other end of the wire through the firewall and attach to either switch terminal. Solder and tape one end of the second piece of new wire to the end of the wire removed from the "S" terminal on the horn relay. Lead the free end of this wire through the hole in the firewall and attach it to the other switch terminal. Install the switch using washers.

Now to test your job. With the switch pushed in, a tap on the horn ring or button should make the horns blow. With the switch pulled to off position, the horns should not blow. If it's the other way around, reverse the two switch wires.

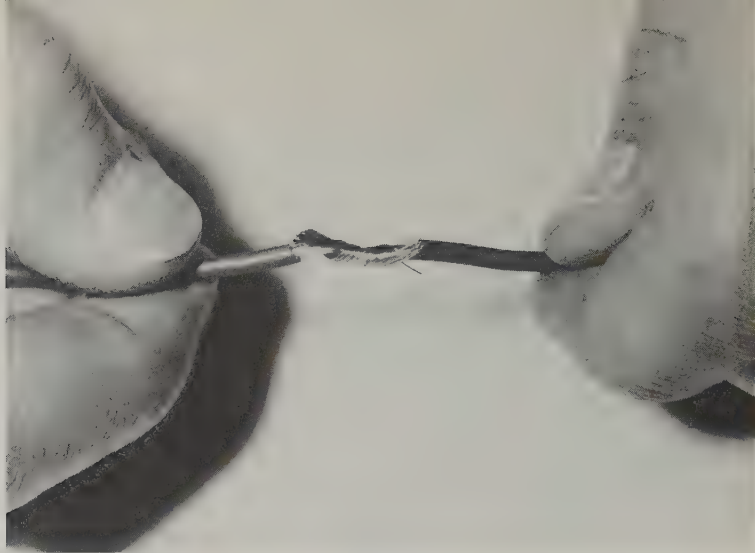
When you leave your car, get in the habit of pulling the switch to the off position. This cuts the horns out completely.

P.W.

See also: ELECTRICITY; ELECTRONICS.



➤ *Twist wires together for solder connection.*



How to Make Electrical Connections

Both soldering and using solderless connections are simple. Of the two, the latter is somewhat easier

TO DO ELECTRICAL WORK on cars, it is frequently necessary to repair damaged connections. There are two popular techniques for making permanent connections: solder and solderless.

To make a solder connection, bare some wire from each end and twist together as illustrated. Hold the soldering iron at the twist and a piece of solder, also as illustrated. When the solder melts and flows into the twist, filling it, the job is done. Insulate the connection with plastic electrical tape, starting one inch from the bared wire and continuing across the twist and onto the insulation of the other piece of wire, also for an inch.

To make a solderless connection, you need a kit which consists of solderless connectors, terminals, and a crimping tool.

There are kits for conventional terminals and others for those insulated with plastic sheaths.

Strip some insulation (about ½-inch from each wire), twist the strands of each wire, but do not join the two wires. Insert one end into the connector and squeeze the end together with the crimping tool. Repeat for the other end and cover with insulating tape if necessary.

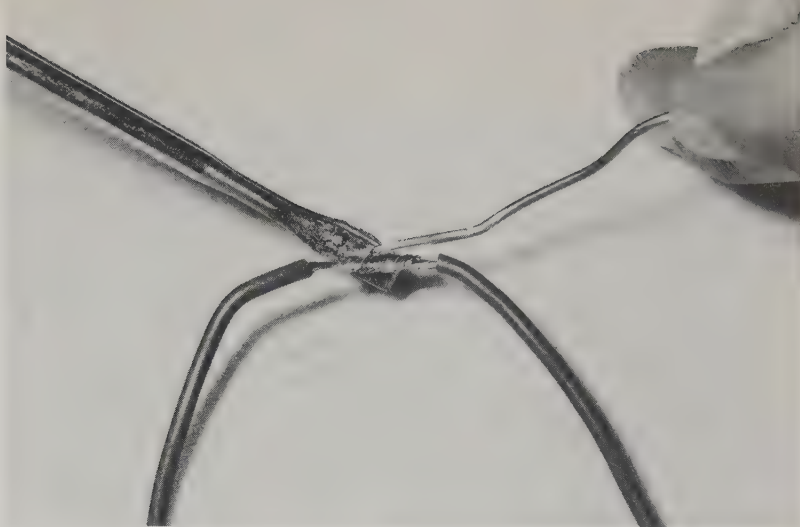
Installing terminals, for screws and spade connections, can also be done with solder or solderless terminals in a similar manner.

Professional mechanics prefer the solderless terminals and connectors because of the speed and simplicity. The solderless kit and terminals cost no more than a good soldering iron and terminals.

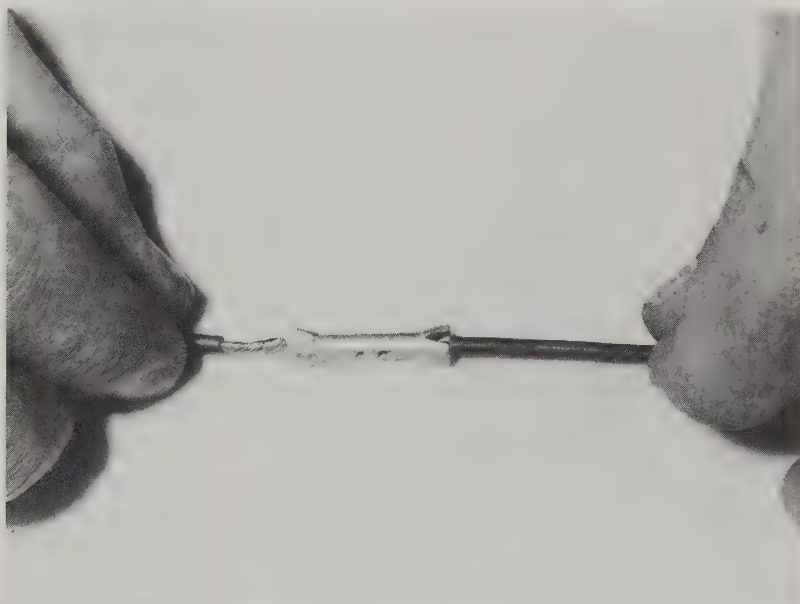
P.W.

See also: ELECTRICITY; ELECTRONICS.

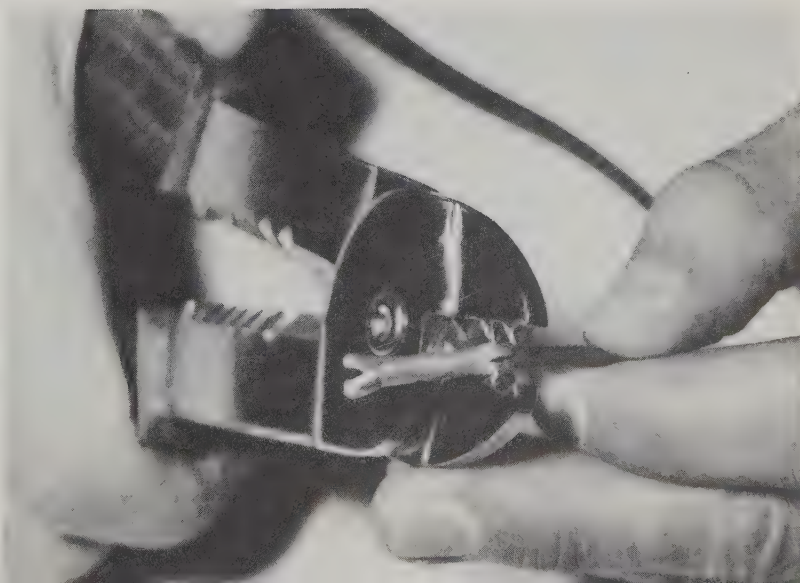
➤ Hold solder and iron so that the twist fills properly.



➤ Typical crimp connector. Strands of each wire are twisted before insertion into connector.



➤ Crimp the ends of the solderless connector. After this, insulating tape is applied, unless connector or terminals are already insulated by a plastic sheath.



How to Understand Electrical Terms

In order to get a better understanding of the electrical world around you, you need to know the meanings of the words used in that world

FUNDAMENTALS ARE, by definition, essential to the understanding of any subject. Electricity is no exception. This article will build up your knowledge storehouse and serve to refresh your memory in areas that were forgotten or poorly understood.

The lingo. Unless it is stated beforehand exactly what is meant by *volt*, *ampere*, *watt*, and *ohm*, we could never be sure that we are talking about the same thing. If each state in the Union had a different definition for the volt, 1.5 volts in Maine might just barely cause a #47 pilot lamp to glow red and 1.5 volts in California might be too much—the lamp's filament could even be vaporized. Hence, electrical definitions determine the electrical standards that are used throughout the world today.

Volt. The volt is the unit of pressure or difference of potential, the practical unit of electromotive force (EMF). One volt is that potential which will maintain a current of one ampere through one ohm of resistance. Voltage is measured with a voltmeter, an instrument that is always connected across (in parallel with) a line or at that point in a circuit where the potential exists.

Ampere. The ampere is the practical unit of current. If one volt is impressed on a circuit with one ohm of resistance, one ampere of current will flow. When one ampere of current is flowing, 6,280,000,000,000,000,000 electrons are moving past a given point in a circuit each second. Current is measured with an ammeter; ammeters are always connected in series with one side of the line and the load.

Ohm. Resistance to current flow in an electrical circuit can be compared to resistance offered to water flow in pipes. The unit of resistance is the ohm. If a circuit has one volt impressed on it, and an ammeter indicates that one ampere of current is flowing, the circuit has a resistance of one ohm.

A length of #14 copper wire (.064 in. dia.) 400 feet long, has a resistance of 1 ohm, but 400 feet of #27 wire (.014 in. dia.) has a resistance of over 20 ohms. The smaller the diameter of wire, the greater its resistance per foot. Wire that is forced to carry current in excess of its rated capacity becomes hot. Heat not only presents a fire hazard but also increases the wire's resistance. Long lengths of wire offer increased resistance to current flow, just as a long pipe line offers increased resistance to water flow, and it is often necessary to increase wire diameter of long lines which are to carry much current, over that ordinarily used.

While current-carrying wire is usually selected for low resistance, some types of materials are used electrically because of their high resistance. For example, an alloy of nickel and chrome, Nichrome, has a very high ohmic resistance and is used in heating elements of toasters, irons, room heaters, and other appliances. Since Nichrome has a high resistance per foot, a shorter length of it can be used to make up a heating element, and because it has high tensile strength, it can become very hot and still retain its form.

Resistors of many kinds are used in electrical circuits to control current flow and to "drop" voltage. These are usually made of high-resistance wire or of carbon, another high-resistance material. A set of simple formulas expresses the relationship of volts, amperes, and ohms in an electrical circuit. These formulas comprise *Ohm's Law*. In the formulas, I stands for current

in amperes; E, for volts; and R, for resistance in ohms. Suppose that 110 volts is impressed on a circuit and we have a 20-ohm resistor in the circuit: how much current will flow through the circuit? Using the second formula, the answer is found to be 5.5 amperes. When any two units are known, the third can always be found by using Ohm's Law.

Watt. The watt is the unit of electrical power. Multiplying volts by amperes gives watts. Many household appliances are rated in watts; electric meters record the number of watt-hours used. A kilowatt is 1000 watts, and 1000 watts used for 1 hour is 1 kilowatt hour.

Watt value can be obtained by multiplication, as stated, in DC circuits, and in alternating current (AC) circuits also—if there is no inductance in the AC circuit. Any device that has wound coils (such as induction motors, chokes, relays) introduces inductance into circuit, however, and when a circuit is inductive, volts times amperes will not give true watts. Incandescent lamps, heaters and other pure resistance devices, are not inductive to any appreciable extent, and in these instances Ohm's Law works.

In fluorescent lamp units, a transformer and a choke—both wound units and highly inductive—are used as part of the ballast control unit. As a result, current lags behind voltage in fluorescent lamps, gets out of step with it, that is, in the rise and fall from zero to maximum value during an alternating cycle and multiplication of volts times amperes will not give true watt value. Therefore, a wattmeter—which has two terminals internally connected to a current coil and placed in the circuit in series with one side of the line, and two other terminals connected across the line, and is designed to record the true watts of an AC circuit—is used to measure true watts regardless of the power factor of a circuit.

See also: ELECTRONICS; WIRING, ELECTRICAL.

Analyzing Your Home Electrical System

Find out if your wiring system is obsolete before you blow a fuse

YOUR NEW RADIAL ARM SAW hums sweetly, ready to slice through that first piece of wood. It bites, then moans and goes dead. Simultaneously, the shop lights flicker and go out. You put in a new fuse or punch the circuit breaker on and try again. Same thing happens.

Disgusted, you go into the den to finish installing that new air conditioner you bought at the same time. You plug it in, then flick the switch to enjoy that first blast of cool air. There is a momentary hum, then silence. The TV goes off at the same time.

You finally have to admit it. The contractor was right when, ten years ago, he advised you to re-wire the old house before remodelling. But at that time you had no idea that you would be buying a power saw, air conditioner, rotisserie, floor polisher, rug shampooer, electric lawnmower—a seemingly endless assortment of power-hungry gadgets, right down to an electric toothbrush. You tried to save money then. Unhappily it will cost a great deal more now to make the necessary electrical improvements.

Even the most modern system will

eventually become obsolete, or at least badly overworked, if more and more demands are made on it. The question is this: How close are you to overloading some or all of the electrical circuits in your home?

You can answer that question quite easily by taking a close look at what the system is doing right now in relation to its capacity. A study made now can save you money tomorrow. You may be forewarned to add some new circuits before remodelling. You may discover that your existing circuits just cannot handle two more air conditioners—or whatever other appliances you have in mind.

At the very least, the study may reveal ways to use your existing circuits more efficiently—for example, plugging cooking appliances so that they will draw current more or less equally from two small appliance circuits rather than mainly from one over-worked circuit. Finally, if you know how your electrical system works, you may be able to cope with future problems more easily. Like knowing that you could tap a little used circuit to power that saw or air conditioner.

The basic system. Before considering

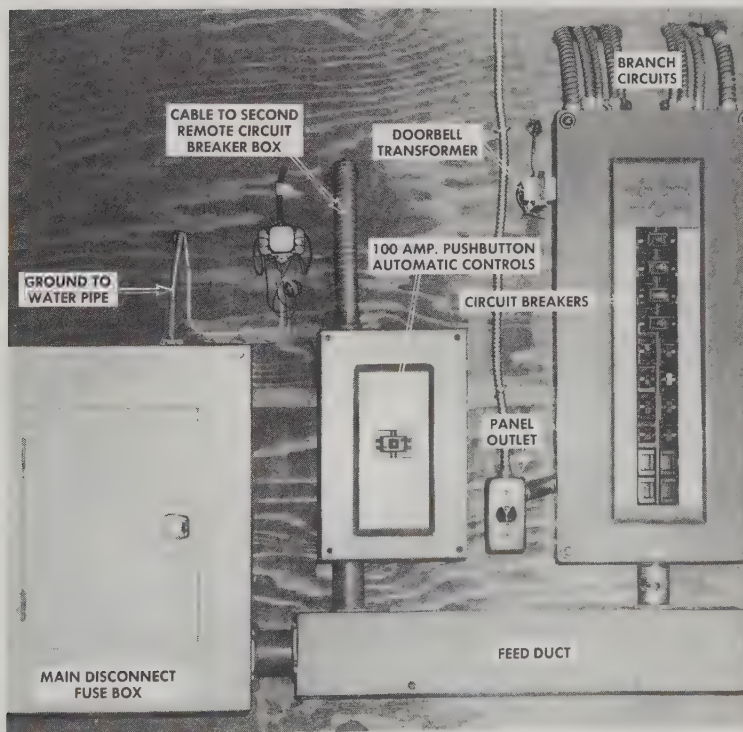


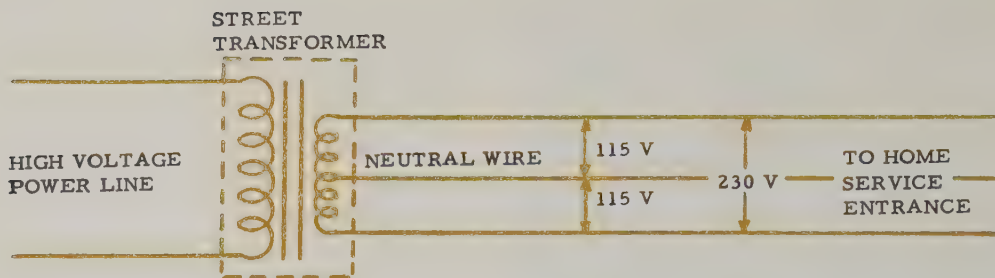
ways to evaluate your electrical system, briefly review how electrical power is brought into the home, and how it is distributed to various parts of the house.

Go outside and look at the cables leading from the street pole to the house. This is the service drop. A modern system has three thick cables plus a thin metal cable that serves only to provide physical support for the power lines. Note that the two "hot lines" are insulated, and that the third (neutral) power cable has no insulation.

These cables go into the *entrance head*, then down a heavy iron pipe to the panel board. On the panel board you will probably find three metal boxes. The first is the main disconnect fuse box which also acts as a cut-off switch when the large main fuses are pulled out. One cable leading from this box is a ground wire that is usually attached to the water pipe, near the water meter. Electricity passing through the fuse box goes into a second box having

▲ Typical hook-up of power lines to home electrical system. Cables run from street to the entrance head, then to meter and inside. ➤





▲ The high voltages in power lines are reduced to a safer level by street transformer. Three-wire service, illustrated above, provides one 230-volt circuit and two 115-volt circuits.

a single pushbutton control switch, and from there into one or more circuit breaker boxes. Small homes require only one circuit breaker box; larger homes often have a second circuit breaker box at some remote location.

Either the main fuse or the pushbutton control box has a label indicating the maximum amperage the system can handle. If your system indicates less than 100 amperes it is definitely out of date. Large homes, or homes having complete air conditioning and many major appliances may have even higher amperage services.

The circuit breaker box is where the various branch circuits start. Each circuit is protected by an individual circuit breaker—the modern equivalent of the old-fashioned and now outmoded fuse. Note that there are several heavy switches for major appliances, such as the range and clothes dryer. The other switches control either 15- or 20-ampere circuits. Fifteen amp circuits are used mainly for lighting and for such plug-in devices as radios, TV, vacuum cleaners and the like. Twenty ampere circuits are used where the electrical loads are expected to be heavier—in the kitchen, dining and family rooms, for example.

Since the terms must be used repeatedly, be sure you understand the differences between amperes, volts and watts.

Amperes indicate the *amount* (or intensity) of electrical current flowing through a

circuit or appliance. It is analogous to the amount of water flowing through a garden hose. Voltage is the electrical *pressure* causing the current flow; it is the electrical equivalent of water pressure. The amount of water able to flow through a hose and the water pressure behind it determine the *power* of the emerging water jet. Similarly, the amount of electrical power (watts) used by a given appliance is the mathematical product of the circuit voltage and the amperes of current drawn by the appliance. This relationship can be used backwards. For example, a 150-watt light bulb operating off a 115-volt circuit draws about 1.3 amperes of current per second (150 divided by 115).

Three wires for economy. Electrical power is pushed along street power lines at very high voltage—usually 4,000 volts. This voltage must be reduced to a relatively safe level by means of distribution transformers mounted on street poles. The standard procedure today is to lead the lower voltage power into homes by means of a 3-wire system that permits tapping off both 115- and 230-volt circuits. These are nominal voltages; the actual voltages range from 110 to 120 volts, and from 220 to 240 volts.

All lights and small appliances in a home operate off 115-volt circuits. Why not the major appliances as well? Mainly because it is more economical to operate heavy power

Analyzing Your Home Electrical System

consuming appliances such as ranges, water heaters and large air conditioners off 230-volt circuits. At higher voltages the appliances use less current; and because less current is required, lighter gauge—hence less costly—wiring can be used.

It is easy to prove that it is so. Remember, that electrical power (watts) is the mathematical product of volts and amperes. Now consider, for example, a 5,000 watt counter range. If this is operated at 115-volts, it would draw about 43.5 amperes of current ($115 \times 43.5 = 5000$). If the same unit is operated at 230 volts, only 21.7 amperes—half the amount—are required ($230 \times 21.7 = 5000$). The amount of power the appliance uses determines how much useful work it can do. The way the required power is supplied determines the cost of installing and operating the appliance.

Appliance wattages. The accompanying table gives some *average* wattages for vari-

ous types of home appliances. These figures indicate only approximate orders of magnitude reflecting the relative power appetites of different appliances. You should not use them to judge your own wiring needs.

When computing power drains on your electrical system, use the actual wattages as indicated on the nameplates of the appliances or in the operating literature supplied by the manufacturer. Sometimes the operating voltage and amperes of current draw are given, instead of the wattage. In such cases you can calculate the wattage by multiplying the volts by the amperes.

Bear in mind that significant changes in operating wattages can occur as new types of appliances are designed and manufactured. If you plan to replace a worn-out appliance, do not be guided by the wattage of the old appliance because the power requirement of the replacement unit may be quite different. For example, ten years ago a typical air conditioner drew about 800 watts; today, the average air conditioner has about twice that wattage. Wattages also vary considerably from one model to another. A kitchen range may require anywhere from 8,000 to 16,000 watts; a water heater may be rated from 2,500 to 4,500 watts.

Estimating service needs. How can you use appliance wattages to evaluate the adequacy of your existing electrical system? Off hand, it might seem quite plausible to simply add together the wattages of all your appliances and compare the total with the power capability of your electrical service. However, this procedure is very likely to suggest that you are close to electrical catastrophe when in fact you have nothing to worry about. The reason is you do not operate all of the electrical devices in your home simultaneously.

Several different methods used to evaluate service requirements are illustrated in the following three examples. In each case

AVERAGE APPLIANCE WATTAGES

Cooking Appliances:

Range	12,000
Counter Range	5,000
Wall Oven	4,000
Microwave Oven	1,600
Dishwasher	1,200
Broiler	1,180
Toaster	1,130
Percolator	1,000
Waste Disposer	800
Freezer	400
Refrigerator	250
Food Mixer	110

Laundry Appliances:

Clothes Dryer	4,500
Washer/Dryer	4,200
Hand Iron	1,000
Washer	700

Miscellaneous Appliances:

Water Heater	3,500
Air Conditioner	1,500
Radiant Heater	1,500
Floor Polisher	335
Television	215
Vacuum Cleaner	210
Fan	200
Electric Blanket	190
Lamp	100
Radio	75
Razor	10
Clock	2

the same size home is assumed (1500 square feet), but the numbers and types of appliances are different.

As you study these examples, note that the computing *methods* differ. Observe also that in two of the examples the major appliances are given their full wattage ratings but that in one example (Case 1) a range rated at 12,000 watts is treated as if it had only a wattage of 8,000.

For more detailed information, including calculations for multiple family dwellings, see Articles 220 and 230 of the National Electric Code.

Case 1. This home is equipped with only the basic electrical necessities. It has no luxury appliances, such as air conditioning.

The general purpose lighting requirement is figured according to a rule of thumb that allows 3 watts per square foot of floor space. Multiplying 1500 square feet by 3 indicates that 4500 watts must be allowed for lights and wall sockets. (This amount

Analyzing Your Home Electrical System

of power could be supplied by three 15-amp circuits or two 20-amp circuits. The circuits must be able to handle a minimum of 39.1 amperes, the figure obtained by dividing 4500 watts by 115 volts. Three 15-amp circuits would handle 45 amps, while two 20-amp circuits could handle 40 amps.)

A total requirement of 9000 watts is indicated when the general purpose, small appliance and laundry wattages are totaled. But these circuits are not used at maximum capacities at any given time. Thus the wattage demand can be adjusted to reflect a more practical demand. The approved formula requires a 100% demand applied to the first 3000 watts, 35% for the next 3001 to 120,000 watts, and 25% for the remainder over 120,000 watts.

In this case the adjusted wattage works out to 5100. To this, another 8000 watts for the range must be added, even though the appliance is rated 12,000 watts. The wattages of other major cooking appliances, such as wall ovens and counter ranges, are similarly adjusted when using this method of computation.

The net computed load works out to 13,100 watts. Since the home is assumed to have a nominal 115/230 volt, 3-wire service, this wattage is divided by the higher voltage (230) to arrive at the final service requirement of 57 amperes.

This indicates that an old-fashioned 60 ampere service would still be satisfactory—right? Wrong! The Code stipulates that when service requirements are computed this way a 100 ampere service is mandatory if the net computed load exceeds 10,000 watts, as it does in this example. The Code is full of such ifs, ands and buts—also some exceptions to the general rules, if you want to dig them out.

Case 2. This example illustrates an optional method of computation that seems more direct, less confusing. General purpose, small appliance and laundry require-

CASE 1				
DESCRIPTION: 1500 square feet, basement and attic unfinished.				
Equipment: 12000 w. range				
Branch Circuits	No.	Watts/Circuit	Total Watts	
General Purpose (15 Amperes)	3 x	1500	=	4500
Small Appliance (20 Amperes)	2 x	1500	=	3000
Laundry (20 Amperes)	1 x	1500	=	1500
▼ -----				9000
3000 watts at 100% demand			=	3000
6000 watts at 35% demand			=	2100
				5100
Range (12,000 watts)				8000
Net Computed Load			=	13,100 Watts
13,100 ÷ 230 (volts)*			=	57 Amperes
Conclusion: 100 ampere service conductors must be used because the net computed load exceeds 10,000 watts.				
*Assume 115/230 volt, 3-wire system.				

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CASE 2

DESCRIPTION: 1500 sq. ft., basement and attic unfinished.

Equipment:

- 12000 w. range
- 2500 w. water heater
- 1200 w. dishwasher
- Five 1800 w. space heaters
- 4500 w. clothes dryer
- 1380 w. (6 amp. x 230 volt) air conditioner

Branch Circuits	No.	Watts/Circuit	Total Watts
General Purpose (15 Amperes)	3 x	1500	= 4500
Small Appliance (20 Amperes)	2 x	1500	= 3000
Laundry (20 Amperes)	1 x	1500	= 1500
Range			= 12000
Water Heater			= 2500
Dishwasher			= 1200
Space Heaters	5 x	1800	= 9000
Clothes Dryer			= 4500
Air Conditioner			= 0000
▼ -----			= 38,200
10,000 watts at 100% demand			= 10,000
28,200 watts at 40% demand			= 11,280
Net Computed Load			= 21,280 Watts
21,280 ÷ 230 (volts)*			= 92.5 Amperes

Conclusion: Dwelling may be served by a 100 amperes service.

ments are figured as in Case 1. However, all major appliances are given their full wattage ratings—with the exception of the air conditioner which is rated zero. The reason is the space heaters consume more power than the air conditioner, and the two types of appliances are never used at the same time.

In this case the adjustment formula requires a 100% demand on the first 10,000 watts and a 40% demand on the remainder of the load. The net computed load works out to 38,200 watts, the service amperage to 92.5 amps. A 100-amp service would be adequate.

Case 3. This example again illustrates how carefully the Code requirements must

be studied. Although the same computation method is used in each case, the methods seem to be different because the air conditioner requirement in this case is treated separately. The rules state that air conditioning must be given a 100% demand rating. If the air conditioners were to be included in the main tally, they would be partly downgraded as are all other contributing appliances. In Case 2 it did not matter where air conditioning was listed because it was rated zero.

Noting this, the computation is easily understood. The space heater is now dis-

CASE 3

DESCRIPTION: 1500 sq. ft., basement and attic unfinished.

Equipment:

- Two 4000 w. wall ovens
- 5100 w. counter range
- 4500 w. water heater
- 1500 w. bathroom space heater
- 1200 w. dishwasher
- 4200 w. washer/dryer
- Six (7 Amp. x 230 volts) air conditioners

Branch Circuits	No.	Watts/Circuit	Total Watts
General Purpose (15 Amperes)	3 x	1500	= 4500
Small Appliance (20 Amperes)	2 x	1500	= 3000
Laundry (20 Amperes)	1 x	1500	= 1500
Ovens	2 x	4000	= 8000
Range (Counter)			= 5100
Water Heater			= 4500
Dishwasher			= 1200
Washer/Dryer			= 4200
▼ -----			= 32,000
10,000 watts at 100% demand			= 10,000
22,000 watts at 40% demand			= 8,800
			= 18,800
Air Conditioners			= 10,100
Space Heater			= 0
Net Computed Load			= 28,900 Watts
28,900 ÷ 230 (volts)			= 125.6 Amperes

Conclusion: Dwelling must have service of at least 126 amperes. "Normal" 100 ampere service would be inadequate.

counted because it requires less power than the air conditioner—just the converse of Case 2. The net computed load is now 28,900 watts (less than in Case 2) but the service amperage is 125.6 amps (substantially more than in Case 2). A 100-ampere service would be inadequate for this home; it must have a minimum of 125.6 amps.

Practical checks. Chances are that you have no need to go through computations such as these unless you are regularly blowing fuses or kicking out circuit breakers. The examples are given mainly to acquaint you with the general nature of your electrical system, and to show how misleading over-simplified analysis could be.

On the other hand, there may be good reason to check out certain heavily used branch circuits—in the kitchen for example. Before buying another kitchen gadget—especially if you already have a large number in use—it might be expedi-

Analyzing Your Home Electrical System

tious to decide in advance whether your small appliance circuits could stand the extra load.

You can easily locate the individual small appliance circuits by knocking out the appropriate circuit breakers one at a time and testing the wall outlets with a trouble light to find out which outlets are on the same circuits.

Having done that, add together the wattages of all the small appliances generally used on any one circuit simultaneously. If the total wattage is in the neighborhood of 1500 watts, you could be asking for trouble by adding another appliance to the circuit. If you are fast with a pencil, you have already figured that both 15- and 20-amp circuits could theoretically handle more than 1500 watts. But, you should never crowd theory too closely in practice. That extra amperage margin is called "safety."

J.H.

See also: HOME IMPROVEMENT; WIRING, ELECTRICAL.

